TM 11-5825-231-25

DEPARTMENT OF THE ARMY TECHNICAL MANUAL

ORGANIZATIONAL DS, GS, AND DEPOT MAINTENANCE

DIRECTION FINDER SET AN/TRD-15

HEADQUARTERS, DEPARTMENT OF THE ARMY

MAY 1966

WARNING

DANGEROUS VOLTAGES EXIST IN THIS EQUIPMENT

Be careful when working on the 115-volt ac line connections. Serious injury or death may result from contact with these terminals.

Do not take chances. Extremely DANGEROUS VOLTAGES exist in the following units of Direction Finder Set AN/TRD–15.

AZIMUTH INDICATOR IP–669/TRD–15
OSCILLOSCOPE 120B/AR

RADIATION HAZARD

Tube types AB2Wa used in this equipment contains radioactive material. These tubes are potentially hazardous when broken; see qualified medical personnel and the Safety Director if you are exposed to or cut by broken tubes.

Never place radioactive tubes in your pocket.

Use extreme care not to break radioactive tubes while handling them.

Never remove radioactive tubes from cartons until ready to use them.

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TECHNICAL MANUAL
No. 11-5825-231-25

HEADQUARTERS
DEPARTMENT OF THE ARMY
WASHINGTON, D. C., *25 May 1966*

Organizational, DS, GS, and Depot Maintenance Manual

DIRECTION FINDER SET AN/TRD-15

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CHAPTER 1

MAINTENANCE INSTRUCTIONS

Section I. GENERAL INFORMATION

1–1. Scope

Note. This is a first edition manual containing preliminary and unreviewed information complied by the manufacturer of the equipment. Judicious caution should be exercised in using the information in this manual until it is replaced by a revised edition.

a. This manual covers organizational, direct support, general support, and depot maintenance for the Direction Finder Set AN/TRD–15. It includes instructions for troubleshooting, testing, aligning, and repairing all units of the system which are not covered by other available manuals. Operating instructions are contained in TM 11–5825–231–10.

b. Direction Finder Set AN/TRD–23 consists of an AN/TRD–15 installed in a shelter with the units rearranged within and between the primary and secondary consoles and the addition of four receivers and an antenna multicoupler. Figures 6–30 through 6–32 furnish interconnection information and shelter and console wiring. The additional receivers are unmodified versions of the R–725(R–390 A) which are covered in TM 11–5820–358–35. A commercial instruction book covering the antenna multicoupler is packed with the AN/TRD–23.

1–2. Modifications and Internal Difference

a. Radio Receiver R725/URR, a component of Radio Direction Finder Set AN/TRD–15, is essentially a modified version of Receiver R390A/URR suitable for DF applications. These modifications include—

(1) Replacement of the IF strip SM–D–535870

(2) Addition of a separate filament supply and magnetic shielding of the receiver VFO assembly to eliminate extraneous FM hum modulation.

The basic maintenance procedures for the R 725 receiver are, therefore, available in TM 11–5820–358–35, which covers the R390A/URR Receiver, as amended by the procedures described in this manual for the modifications performed.

b. Monitor Oscilloscope SM–B–535704 is a standard, commercially available oscilloscope. Technical information contained herein is reproduced with the permission of Hewlett-Packard from their manual 01260–1 for Model 120 B/AR Oscilloscope. Future direction finder sets may contain a military approved equivalent with associated documentation

1–3. Items Not Covered

Items which are a part of the overall system but not covered in detail in this manual are—

Accessories (SM–B–535703)
Receiver, Radio R–390A/URR
Canvas Storage Bags (SM–C–132812, SM–C–535765)

SECTION II. GENERAL THEORY

1–4. Basic Principles

a. Signal Source. A wavefront intersects an antenna array of a direction finding system which computes a line perpendicular to the front and intersecting the source of transmission. The reciprocal ambiguity of the computed line perpendicular to the wavefront is removed by appropriate system blanking, resulting in a unidirection presentation.

b. Bearing Errors.

(1) *Computing.* Inherent inaccuracies in the system account for bearing errors to the degree permitted by specification SC–A–46753B. Wavefront distortions, resulting in computed bearing errors, are caused by irregularities in the terrain, obstacles, or reflecting objects around an antenna installation of a direction finding set.

(2) *Polarization and propagation.* Wavefront distortions are introduced by horizontally polarized components of the electrical field under certain conditions of transmission (night effects) resulting in errors of bearing computation. Bearing errors arise in propagation because the transmitted waves do not travel over a great-circle path.

1–5. System Theory

a. General (fig. 1–1). The Direction Finder Set AN/TRD–15 presents a continuous and accurate bearing display formulated by sequential sampling and processing of selected waveform interceptions from each of twenty-five circularly arranged antennas. The system operation is illustrated in the system block diagram (Fig. 1–1).

b. Tracing System Signal Paths (fig. 1–2). The reception of a signal and the related processing to give direction indicating information is traced through the units of the system in *c* below.

c. How Direction Finding is Accomplished.

(1) Radio waves travel outward in space from a transmitting antenna with the speed of light somewhat in the same manner that water wavelets travel (at a much lower speed) outward from a disturbed water surface. The radio wave has the same phase at all points which are at the same distance from the transmitting antenna. The "same phase" means that the waves arrive simultaneously at the points which are equidistant from the transmitter.

(2) Points which are equidistant from the transmitter are said to lie on an imaginary "equiphase surface". The more common name for an equiphase surface is "wave front". Wave fronts in free space are always spherical since all points equidistant from a single point must lie on the surface of a sphere. This point, the center of the imaginary sphere, is the transmitter site. The spherical curvature of the wave front is quite pronounced near the transmitter site. At greater distances, the curvature is so slight over the area covered by an antenna that, for most practical purposes, a wave front may be considered to be a plane surface. Any line perpendicular to an undistorted wave front passes through the transmitter. A direction finder locates an equiphase surface or wave front. The direction to the transmitter is then assumed to be perpendicular to the wave front (fig. 1–4).

d. General Theory of the Doppler Direction Finder.

(1) If a signal is received by a moving antenna it will experience a phase modulation in accordance with Doppler's principle. When the radiation field has essentially plane and equiphase wave fronts and the antenna is placed in simple rotational motion about a reference point, as in figure 1–4, the signal intercepted by the antenna will experience a sinusiodal phase modulation.

(2) The frequency of this modulation is that of the rotating antenna and the phase of the modulation in uniquely related to the direction of arrival of the radiation field. Measurement of this quantity, therefore, permits the unambiguous determination of the direction of arrival of a radiation field.

e. General Theory of the Quasi-Doppler Direction Finder.

(1) The principle of operation of the Quasi-Doppler direction finder is identical to the preceding with one additional variation. Instead of physically rotating an antenna through the radiation field this function is simulated by switching the outputs of a

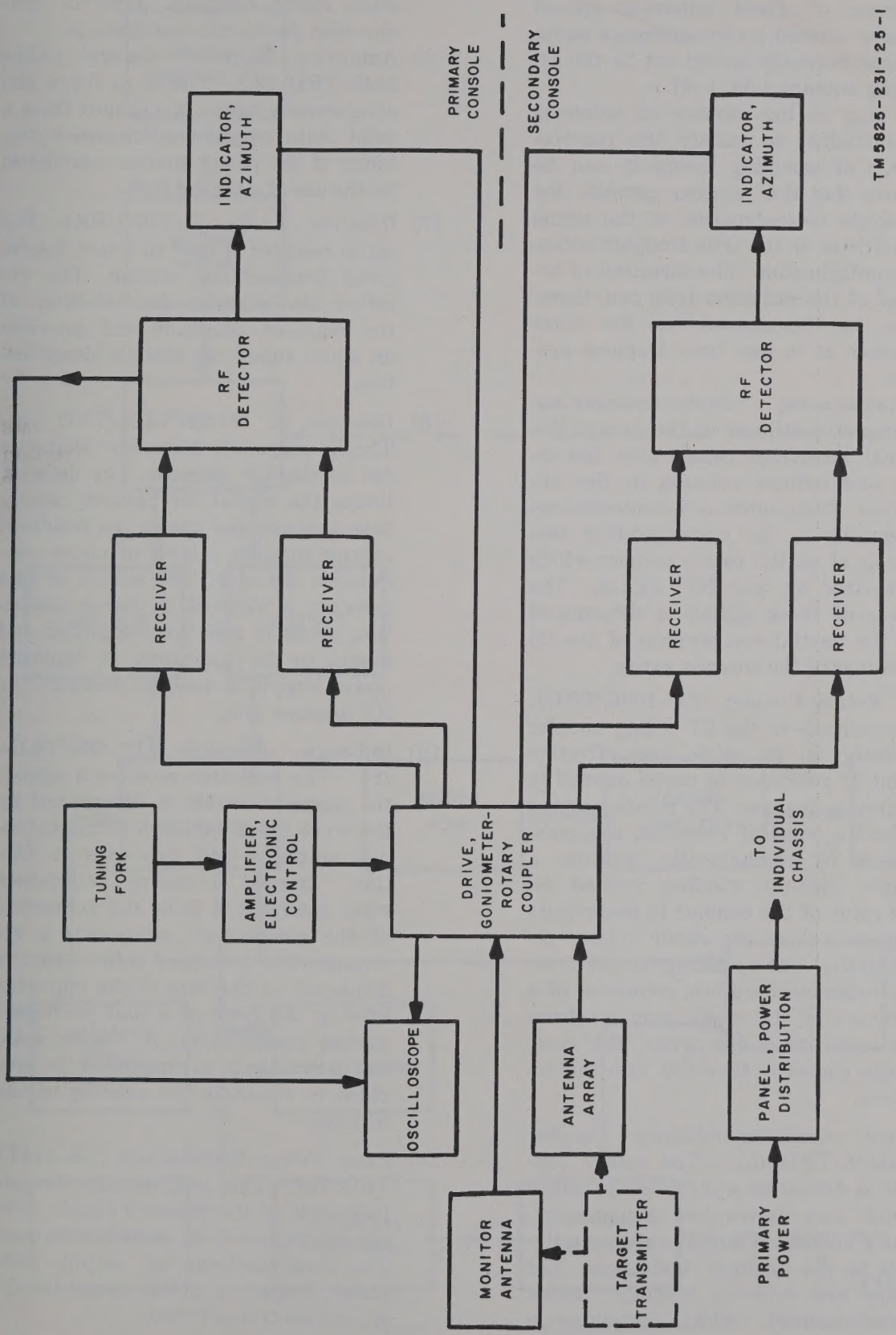

Figure 1-1. Overall system, block diagram.

number of fixed antennas spaced equally around a circumference equal to that normally traced out by the rotating antenna (fig. 1-4).

(2) As long as the number of antennas is sufficient to satisfy the requirements of sampling theory it can be shown that this system permits the accurate reconstruction of the signal conditions of the true Doppler antenna configuration. The direction of arrival of the radiation field can, therefore, be determined in the same manner as in the true Doppler system.

(3) Antenna array. Simple monopole antennas are utilized in the array. The signal wavefront passes over the array and induces voltages in the antennas. Each antenna is connected sequentially to the corresponding terminals of an RF rotary coupler which is excited by the RF signals. The phase of these signals is determined by the spatial relationship of the 25 antennas of the antenna array.

(4) RF Rotary Coupler (CU-1096/TRD). The purpose of the RF rotary coupler assembly is to cause the effective point of reception to travel around in a circular manner. The rotation of the effective point of reception is accomplished by mechanically rotating a single pick-up winding located on the rotor of the coupler to electrically engage each of the stator inputs sequentially. The resulting output from the rotor is, therefore, composed of a sequence of RF signal samples from the antennas of the array. This composite signal is then fed into the receiver.

(5) Drive, Goniometer-Rotary Coupler (TG-26/TRD-15). The rotary coupler is driven by a synchronous motor which also drives two goniometers. The goniometers supply reference signals to the azimuth indicators. The motor also drives a magnetic device (synchronizer) which produces a steep rising electrical pulse to synchronize the monitor oscilloscope.

(6) Amplifier, Electronic Control (AM-3545/TRD-15.) Power to drive the synchronous motor is obtained from a solid state amplifier. Frequency stability of the power source is achieved by the use of a tuning fork.

(7) Receiver, Radio (R-725/URR). The radio receiver is used to select the desired transmitting station. The receiver also permits the selection of the required passband and provides an audio signal for station identification.

(8) Detector, R F (RF 159/TRD 15). The IF output of the radio receiver is fed to the RF detector. The detector limits the signal to remove amplitude changes and passes the resultant carrier through a type of phase modulation detector. The output of this detector is filtered to lessen distortion products and then amplified and passed to the indicator. A separate power supply is used to energize the RF detector unit.

(9) Indicator, Azimuth (IP-669/TRD-15). The indicator receives a signal, the phase of which is determined by the wave front approach to the antennas, amplifies and processes it further. Special circuitry determines what quadrant it is in and by means of the goniometer, establishes a reference. The processed information is displayed on the face of the indicator tube in the form of a half propeller-shaped presentation. A degree scale and a crosshair arrangement is provided to facilitate the reading of the display.

(10) Pane, Power Distribution (SB-1747/TRD-15). This unit permits the adjustments of the primary supply voltage by means of an autotransformer. The panel contains an output voltmeter, frequency meter, circuit breaker, and control switches.

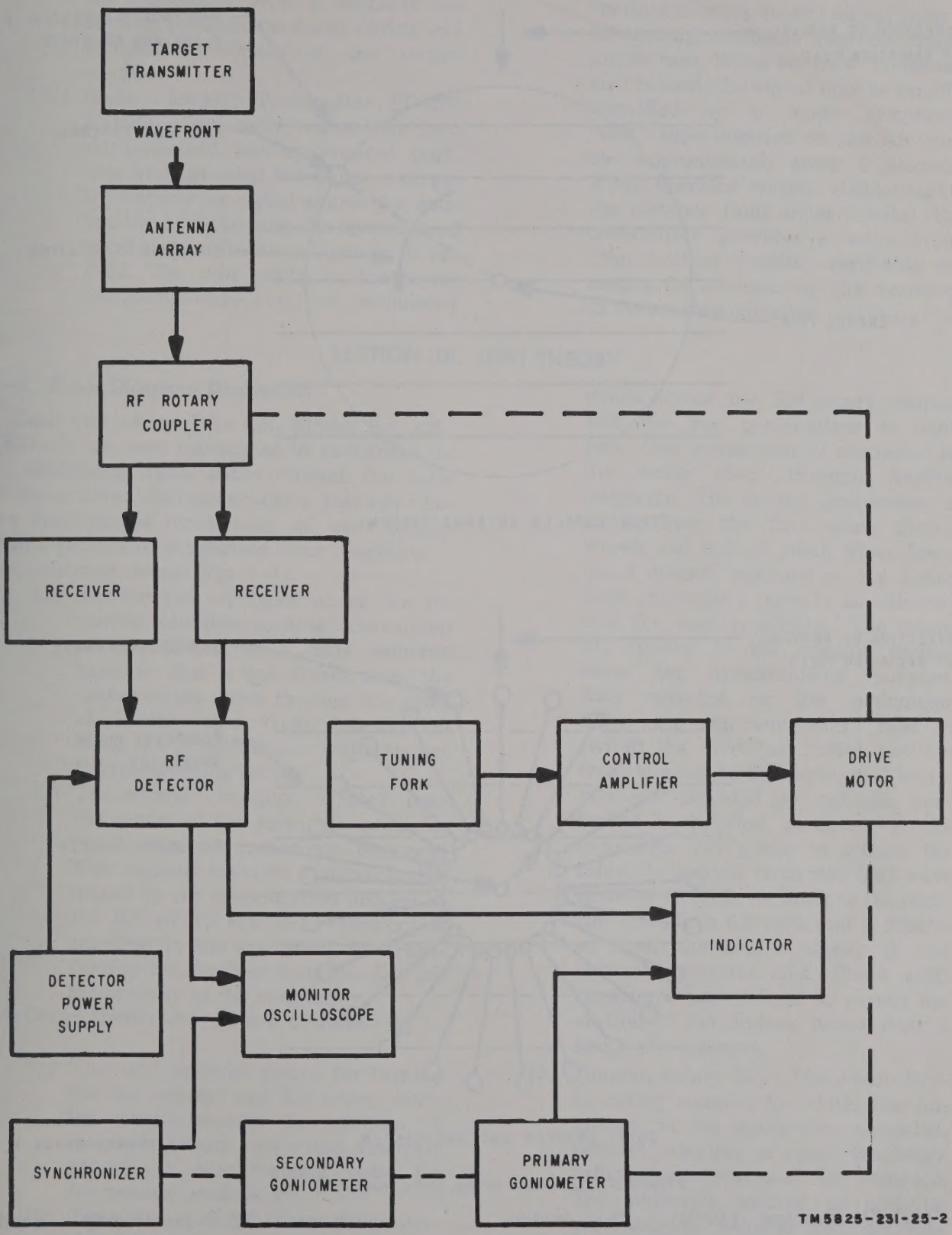

Figure 1-2. Tracing signal paths.

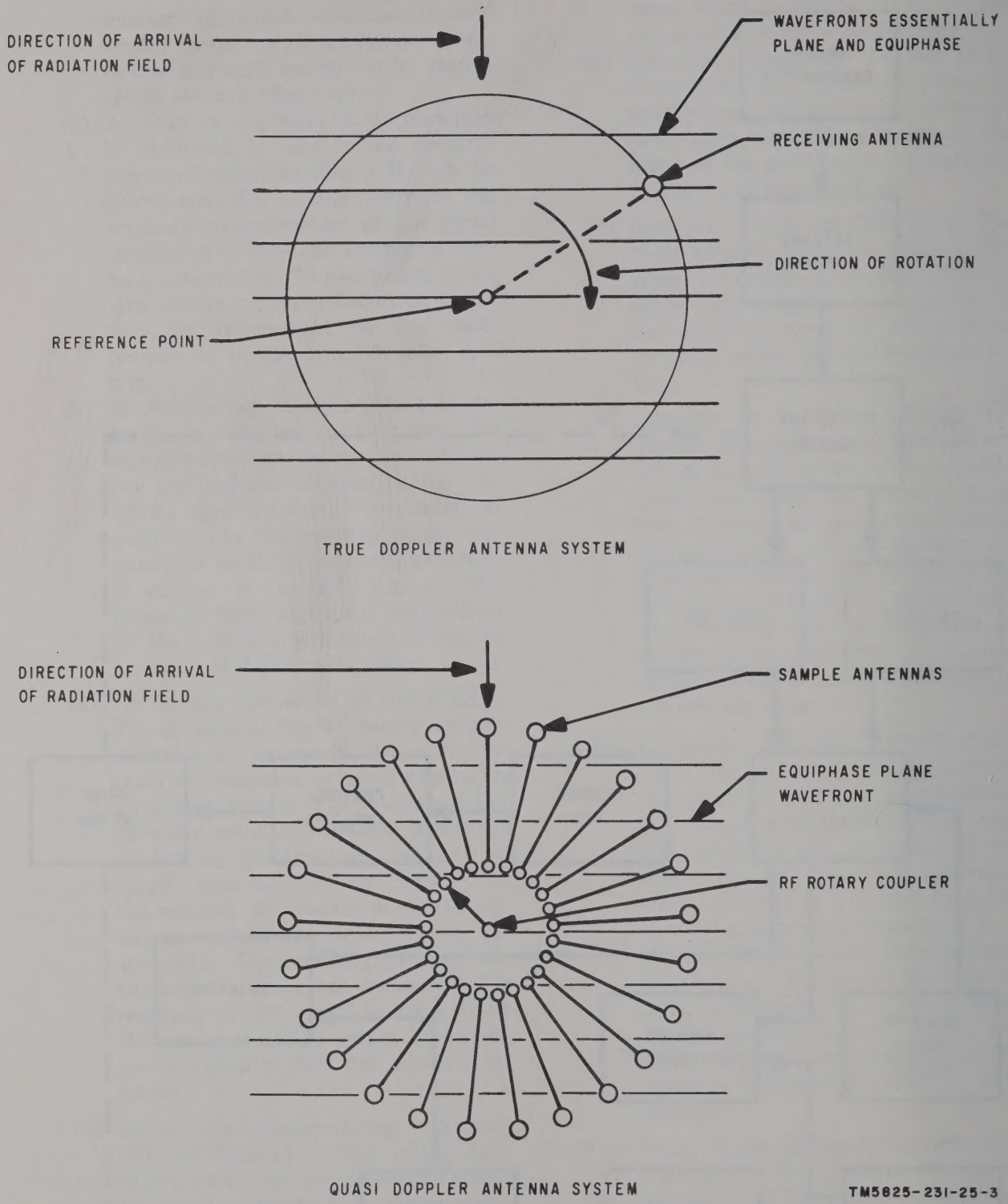

Figure 1-4. Antenna array, wave front diagram.

(11) Oscilloscope (120B). This instrument is a standard Hewlett-Packard model 120B provided for the purposes of monitoring and testing. A synchronizing pulse is available from the magnetic device in

the goniometer drive to assist in observing patterns produced during one complete revolution of the rotary coupler.

(12) Radio (Target) Transmitter (T-279 A/UR). The radio transmitter is a self-contained, battery-powered portable unit intended for use as a target transmitter or signal source for calibrating and checking the operation of the direction finder equipment in the field. The unit emits a low-power continuous-wave (cw) or modulated continuous-wave (mcw) signal from a telescoping monopole atop the transmitter case. When an mcw transmission is used, the signal may be readily identified by an audio frequency "tick" superimposed on the RF carrier approximately every 2 seconds. When operated within visible sighting distance (and under 1 mile), the transmitter provides a wave front (fig. 1-2) of precise, verifiable direction for determining the accuracy of the bearing indicator.

SECTION III. UNIT THEORY

1-6. Block Diagram Discussion

Each unit of the Direction Finder Set AN/TRD-15 has been introduced in paragraph 1-5*e*, describing signal paths through the units of the system. Subparagraphs *a* through *i* below describe the functioning of each briefly with reference to supporting block diagrams.

a. Antenna Array (fig. 1-4).

(1) The circular arrangement of the receiving antennas permits interception of wave fronts on a time sequence basis so that a line drawn from the center of the circle through the point of initial wave front interception along the circumference will intersect the transmitting source.

(2) The monitor antenna, located near the center of the array, is used for monitoring and reference purposes. This antenna provides a signal undisturbed by the commutation process of the RF rotary coupler. Circuitry is provided in the equipment for transferring the receiver from the DF antenna array to the monitor.

b. Drive, Goniometer-Rotary Coupler (fig 1-5).

(1) This unit provides means for turning the goniometers and RF rotary coupler simultaneously. In addition, a magnetic pickup and wheel assembly provides a synchronizing pulse for the monitor oscilloscope.

(2) The drive motor 2-phase, is a synchronous type (115-volt, 180-cycle) which drives the RF rotary coupler and the two goniometers at 5400 rpm. One goniometer is connected to the motor shaft through flexible couplings. The second goniometer is driven from the first using timing wheels and belt. A small wheel housing a magnet mounted on the motor shaft generates a pulse in an adjacent coul for each revolution. The pulses are applied to the monitor oscilloscope for synchronizing purpose. Also mounted on the goniometer drive unit are four relays used to switch the direction finder position from monitor to df operation. The relays are actuated by voltages controlled by switches mounted on the indicators. DC power to actuate the relays is derived from two half-wave rectifier circuits. Ac input to the rectifier circuits is 6.3 volts and is obtained from the heater supply in the azimuth indicator unit. Phase shift capacitors are utilized to permit operation of the 2-phase motor from a single-phase source.

(3) Coupler, rotary RF. The motor-driven rotary coupler, to which the antennas of the array are connected, permits sampling of radio frequency information from each in sequence. The inductive method of coupling used assures reliable and accurate transmission of information from the

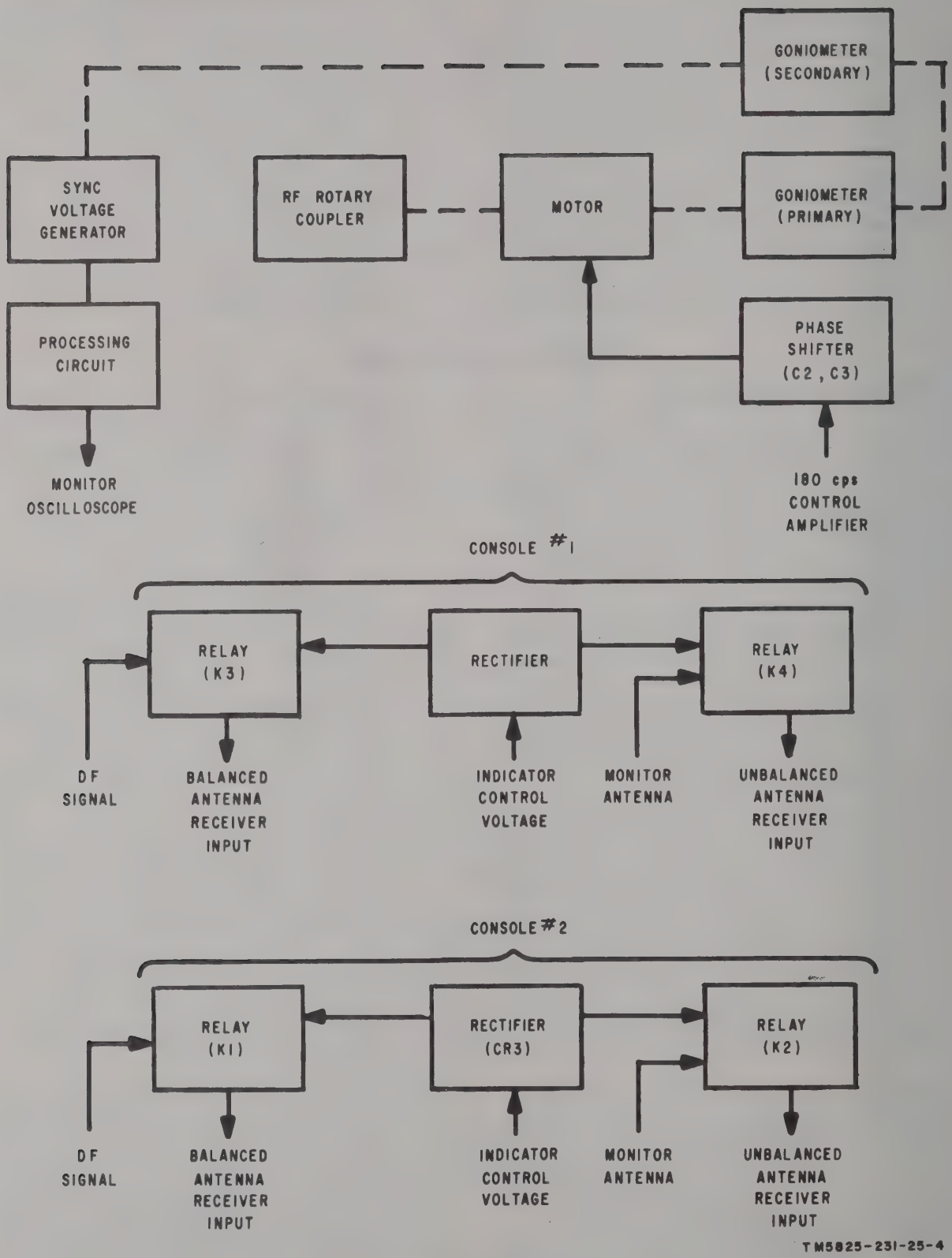

Figure 1–5. Drive, goniometer-rotary coupler, block diagram.

antennas to the input of the radio receiver.

(4) Goniometer, primary. The motor-driven primary goniometer produces a horizontal and a vertical sweep voltage for the primary indicator resulting in a displayed radial sweep which, when modulated by direction finding information, produces a half-propeller indication of bearing.

(5) Goniometer, secondary. Belt-driven from the primary goniometer, the secondary unit functions similarly to provide sweep voltages for the secondary indicator. Thus, bearing indications from two transmitting sources may be viewed simultaneously.

(6) Sync Voltage Generator. A magnetic pickup device, mechanically coupled to the secondary goniometer, is used to develop a pulse for each revolution of the goniometer. Shaping of the pulse is accomplished in the processing circuit to develop a slope suitable for synchronizing the monitor oscilloscope.

(7) Relay operation. Relays for selecting the m ode of receiver operation for the primary and secondary consoles are mounted on the goniometer drive chassis. Operation of the relays energized by a rectified voltage to eliminate relay chatter, permits the operator to shift the receiver input to an antenna (monitor) containing no direction finding information.

c. Amplifier, Electronic Control (fig. 1–6).

(1) The electronic control amplifier contains a tuning fork voltage source and an appropriate power amplifier to raise this signal to a level sufficient to drive the motor of the drive chassis.

(2) The 180-cps output from the tuning fork is fed to an isolation stage and a safety circuit. After sufficient power amplification, the elements of the output stage are switched alternately into conduction to provide the voltage swing across the output transformer secondary necessary to drive the motor.

(3) The safety circuit continuously monitors the load on the amplifier output and if below a preset level it will shut down the signal fed to the out put stage.

(4) The power supply provides dc voltage for the power stages. Regulation is provided to protect the low level stages from large voltage variations.

d. Receiver, Radio (R 725/URR).

(1) The receiver is utilized to select the desired signal from those present in the frequency range of 1.5 to 20 mc. The receiver provides cw (continous wave), mcw (modulated continuous wave), and am (amplitude modulated) reception over a frequency range of .54 to 32 mc. The receiver is basically a superheterodyne of the multiple conversion type. Triple conversion is used for lower frequencies (.5 to 8 mc) and double conversion for the higher frequencies (8 to 32 mc). The receiver normally operates from a self-contained power supply designed to operate at a nominal input of 115 or 230 volts over a frequency range of 48 to 62 cps. However, provision is made to use a dynamotor in place of the ac power supply for dc operation.

(2) The tuning system of the R–725/URR provides linear tuning over the entire frequency range of the receiver Permeability tuning (insertion of powdered-iron cores into coils) and a system of gears and cams makes linear tuning possible and permits the use of a counter-type indicator on the front panel to show the frequency selected.

(3) The receiver power supply provides dc for the antenna and break-in relays, ac to the filament and over circuits, and B+ voltage to the voltage regulator circuit. All B+ voltages supplied to the receiver are regulated. The voltage regulator circuit consists of a series regulator, a dc amplifier, and voltage reference tubes. The power supply consists of a transformer and two rectifiers. The

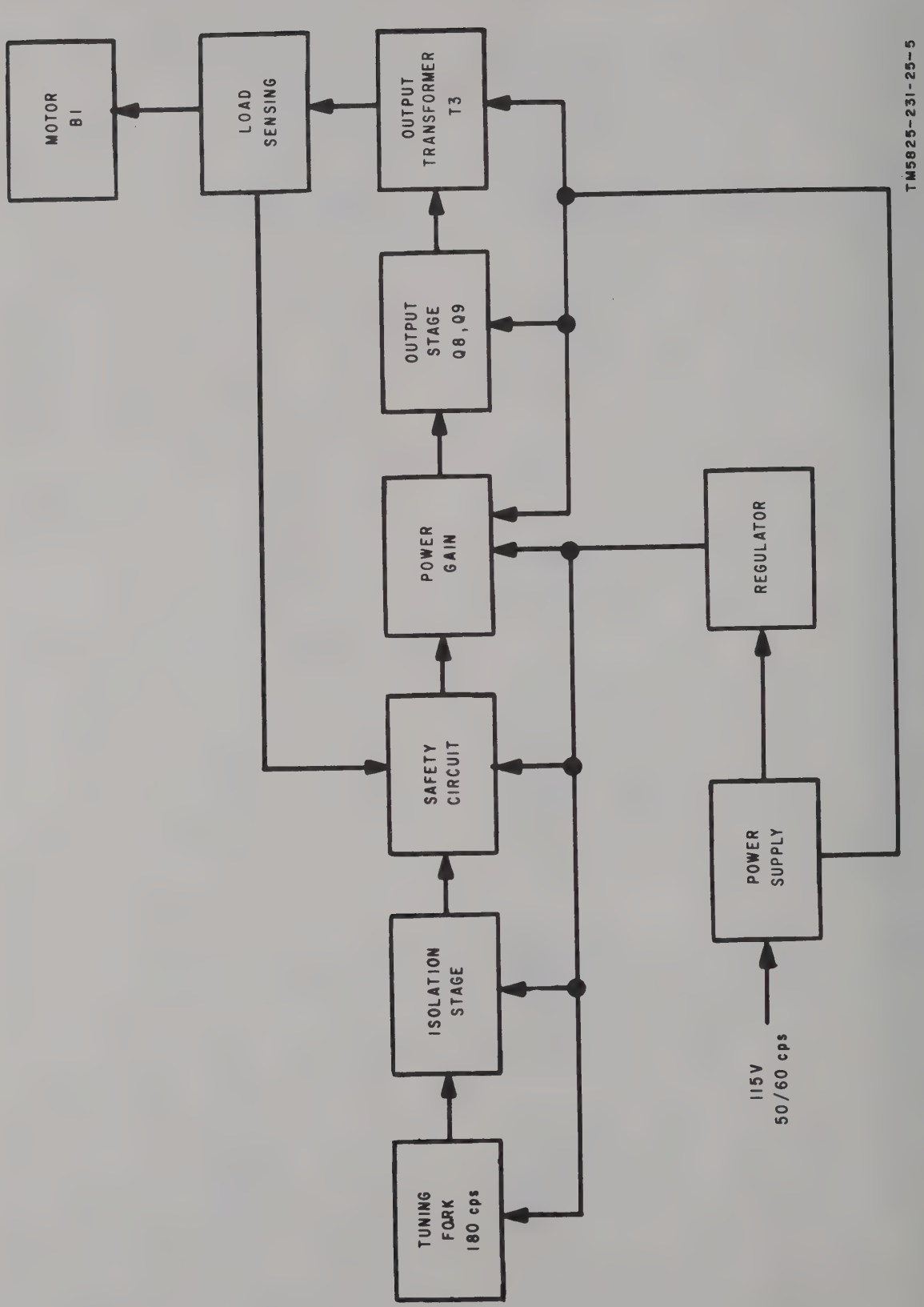

Figure 1-6. Amplifier, electronic control, block diagram.

transformer has two primary windings which are connected in series for 230-volt operation and in parallel for 115-volt operation.

(4) A special IF strip is installed in a standard R–390A/URR radio receiver to provide proper phase response in the receiver suitable for accurate direction finding usage. The operator using this receiver may be slightly mistuned and still receive a good bearing indication. At his option, the operator may select to monitor a transmission without interfering direction finding information by switching the receiver input to the single-monitor antenna.

(5) IF strip (fig. 1–7). The IF chassis contains six voltage amplifier stages in addition to detector, agc, bfo, limiter and cathode follower stages. The desired bandwidth is obtained through the use of tuned circuits, as compared with mechanical filters used in R–390A/URR receiver. A 455-kc signal from the third mixer stage of the radio receiver is amplified in the first four stages of the IF amplifier. The fifth IF stage provides signals for further processing to an agc circuit, a cathode follower output stage, and a sixth IF stage. The agc circuit develops a controlling dc voltage for maintaining the output of the amplifier at a constant level. The cathode follower provides a low impedance (50 ohms) output for external use. The sixth IF stage mixes a signal from the bfo to produce a beat frequency for the detector

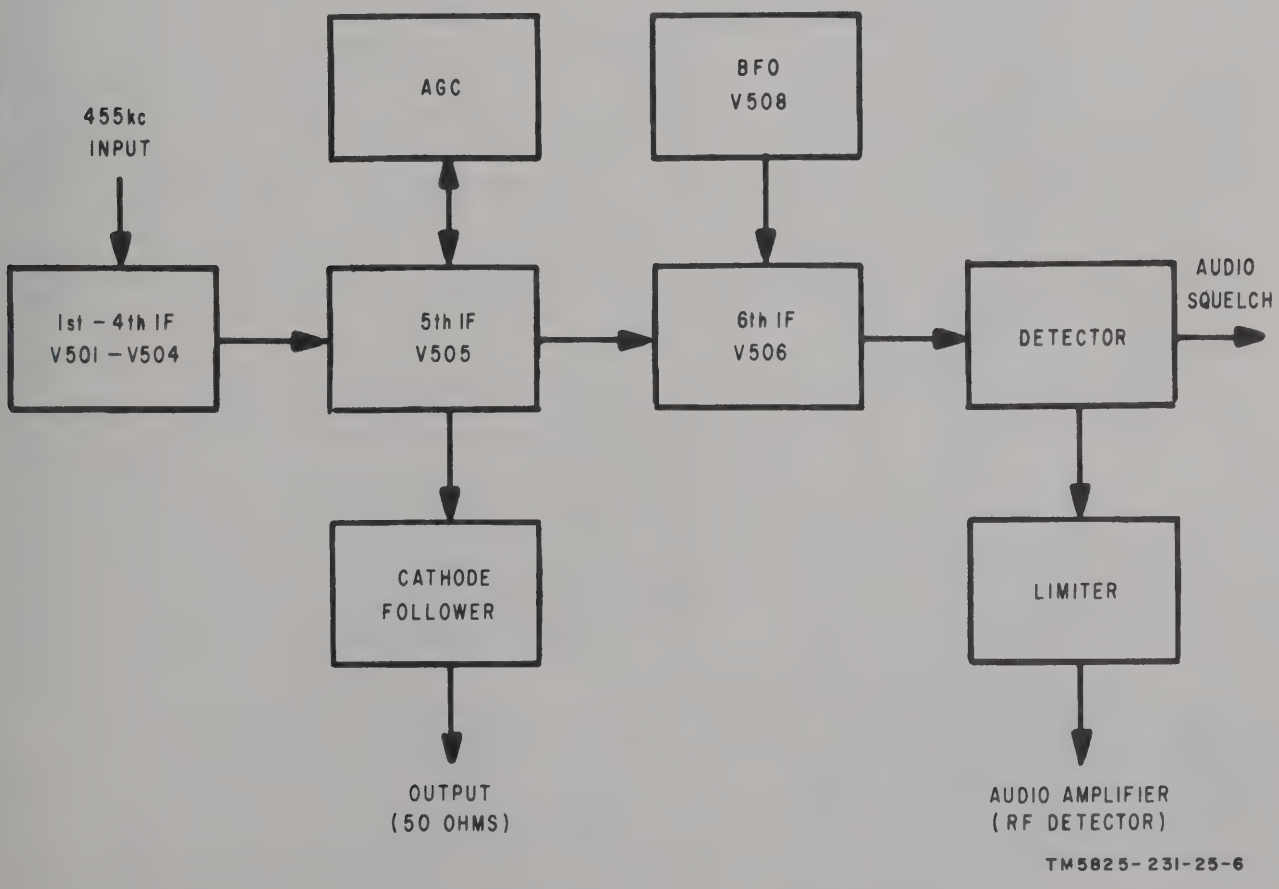

Figure 1–7. IF amplifier, block diagram.

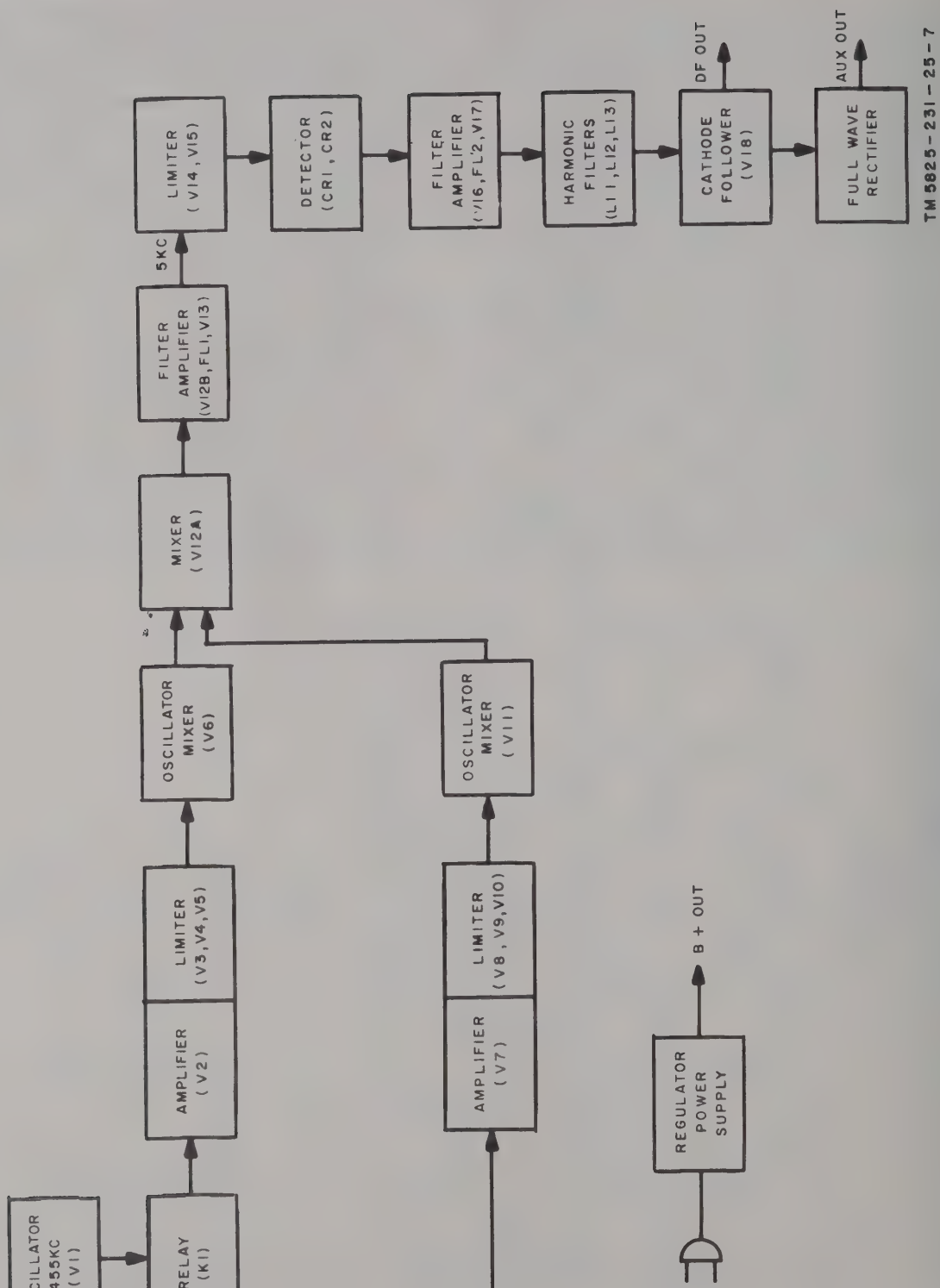

Figure 1-8. RF detector, block diagram.

where an audible frequency is produced for monitoring an unmodulated carrier. The audio output of the detector is passed through a limiter stage to remove noise peaks. The detector also provides a dc signal for the squelch circuit to quiet the audio when the received signal drops below a predetermined level.

e. Detector RF (Fig 1–8).

(1) The RF detector converts AM, FM, PM, or FSK signals from the IF output of the receiver(s) into acceptable form for direction finding display.

(2) The signal from the first receiver passes through the amplifier/limiter stages and mixes with an oscillator to produce a difference frequency of 95 kc.

(3) The signal from the second receiver (or the 445-kc oscillator as determined by relay K1) passes through the amplifier limiter stages and mixes with an oscillator to produce a difference frequency of 100 kc.

(4) The 95-kc and 100-kc signals combine in a mixer to produce a 5 kc-signal which is filtered, amplified and limited for the phase detector. The demodulated signal (90 cps) is further amplified and filtered to remove harmonics finally appearing at the output of a cathode follower as an acceptable signal for df display.

(5) A rectified version of the df display signal is available as an auxiliary output.

(6) The power supply, receiving primary power from the power distribution panel, provides regulated dc voltage to energize the RF detector unit. Full wave retification and series controlled regulation are employed.

f. Indicator, Azimuth (fig. 1–9).

(1) The azimuth indicator accepts the signal from the RF detector, references it to goniometer output information, and presents the result as a half-propeller visual display.

(2) Direction finding information from the RF detector is amplified and full-wave rectified to modulate the oscillator carrier in the control modulator before energizing the rotor of the goniometer. The stators provide the modulated radial sweep necessary for df display on the CRT.

(3) A portion of the direction finding information from the detector is processed in the clipper and sensing circuits to provide blanking of the unwanted half of the propeller display.

(4) A low voltage, regulated dc supply energizes all circuitry except the CRT.

(5) A high voltage dc supply provides voltages for aperating the CRT. A switch to short the df signal and reduce the intensity at the CRT enables the operator to monitor a signal without a display on the CRT.

g. Panel, Power Distribution (fig. 1–10).

(1) Source voltage of 115 or 230 vac ± 10 percent may be connected to the power panel with an assured 115-vac output by the selection of the appropriate tap on the autotransformer.

(2) Three output receptacles (grounded type) are provided for connection of the load.

(3) Circuit breakers provide adequate overload protection.

(4) Panel meters display voltage and frequency delivered to the system.

h. Oscilloscope (Hewlett-Packard 120B) (fig. 1–11).

(1) The monitor oscilloscope consists of five major functional circuit groups; the vertical amplifier, the sweep generator, the horizontal amplifier, the low voltage power supply, and the high voltage power supply.

(2) A vertical input signal is converted into two 180° out-of-phase amplified signals which are applied to the CRT for vertical deflection and to the TRIGGER SOURCE switch when they are used as the INT+ and INT sync signals.

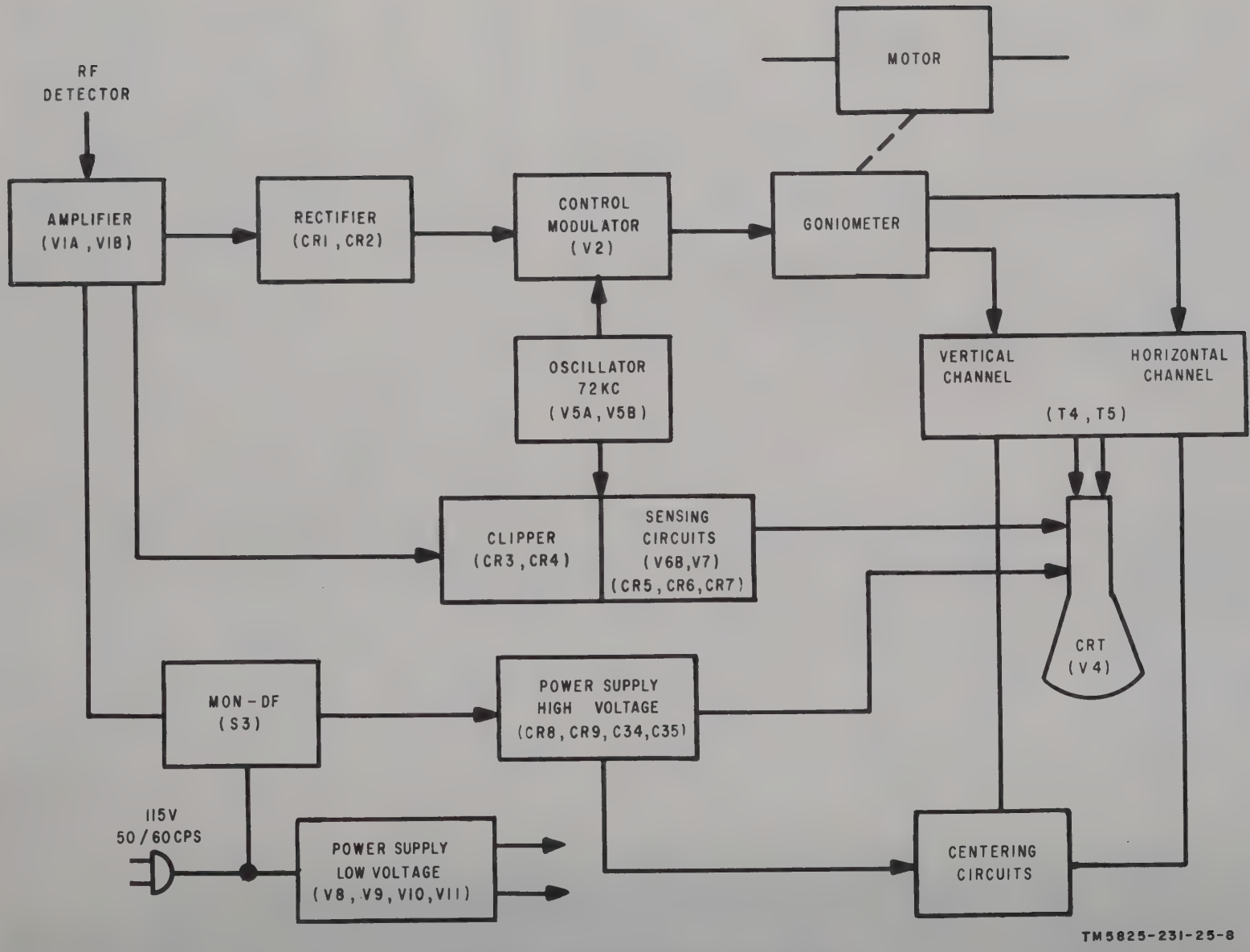

Figure 1–9. Azimuth indicator, block diagram.

(3) The horizontal or sync input signal is applied, depending upon the setting of the HORIZONTAL DISPLAY switch, to either the TRIGGER SOURCE switch (to be used as the external sync signal), or to the horizontal amplifier (to be used as the external horizontal input signal). In addition, 6.3 vac is available at the TRIGGER SOURCE switch to provide for a sync signal repetition rate equal to the line frequency.

(4) The sync signal selected by the TRIGGER SOURCE switch is applied to the sweep generator, where the sync signal initiates the horizontal sweep signal and the unblanking gate. The sweep generator applies the sweep signal to the horizontal amplifier and the resultant amplified sweep is applied to the CRT as the horizontal deflection signal. The unblanking gate is applied to the high voltage power supply. If an external horizontal sweep is applied instead of the sweep from the sweep generator, the external sweep is amplified by the horizontal amplifier and applied to the CRT.

(5) The low voltage power supply generates the voltages required by the high voltage power supply, the vertical and horizontal amplifiers, and the sweep generator.

(6) The high voltage power supply generates the high voltages for the CRT. The unblanking gate and Z axis signals effectively alter the value of the power supply voltages to allow unblanking and modulation of the CRT intensity.

i. Radio Transmitter (T–279A/UR) (fig. 1–2).

(1) Radio Transmitter T–279A/UR is a low-power amplitude modulated or continuous wave target transmitter with a frequency range of 0.50 to 30 mc. The transmitter is comprised of four major functioning circuit groups, the RF oscillator, the RF amplifier, the IF oscillator, and the relaxation oscillator which are battery powered.

(2) RF oscillator. The output frequency of the Hartley type RF oscillator is determined by a resonant circuit. The particular frequency range desired is obtained by selecting the proper inductance, and the frequency within this range is selected by rotating a variable capacitor.

(3) RF amplifier. The RF amplifier amplifies and isolates the RF oscillator from the antenna circuit, preventing variations in output capacitance from affecting the oscillator frequency.

(4) AF oscillator. The af oscillator produces an audio frequency voltage which is applied to the grid of the RF amplifier when an amplitude modulated signal is desired.

(5) Relaxation oscillator. The neon panel lamp in the relaxation oscillator circuit flashes intermittently (about once every 2 seconds) to indicate that the transmitter is on and that the relaxation circuit is producing an audible "tick" on the transmitted signal for identification purposes.

(6) Power supply. The power supply for the transmitter consists of one 1.5-volt battery BA–404/U and one 135-volt battery BA–424/U.

1–7. Stage Analysis

Each unit of the Direction Finder Set AN/TRD–15 has been discussed in paragraph 1–6 on a block diagram basis. Subparagraphs *a* through *j* below contain a complete circuit analysis of each stage with supporting schematics of each major unit.

a. Antenna Array (fig. 1–13).

(1) The receiving antenna array used in an AN/TRD–15 Direction Finder Set installation consists of a series of monopoles arranged on the circumference of a circle having a radius of 75 feet. Twenty-six monopoles make up the entire array. Twenty-five are located at equal distances along the

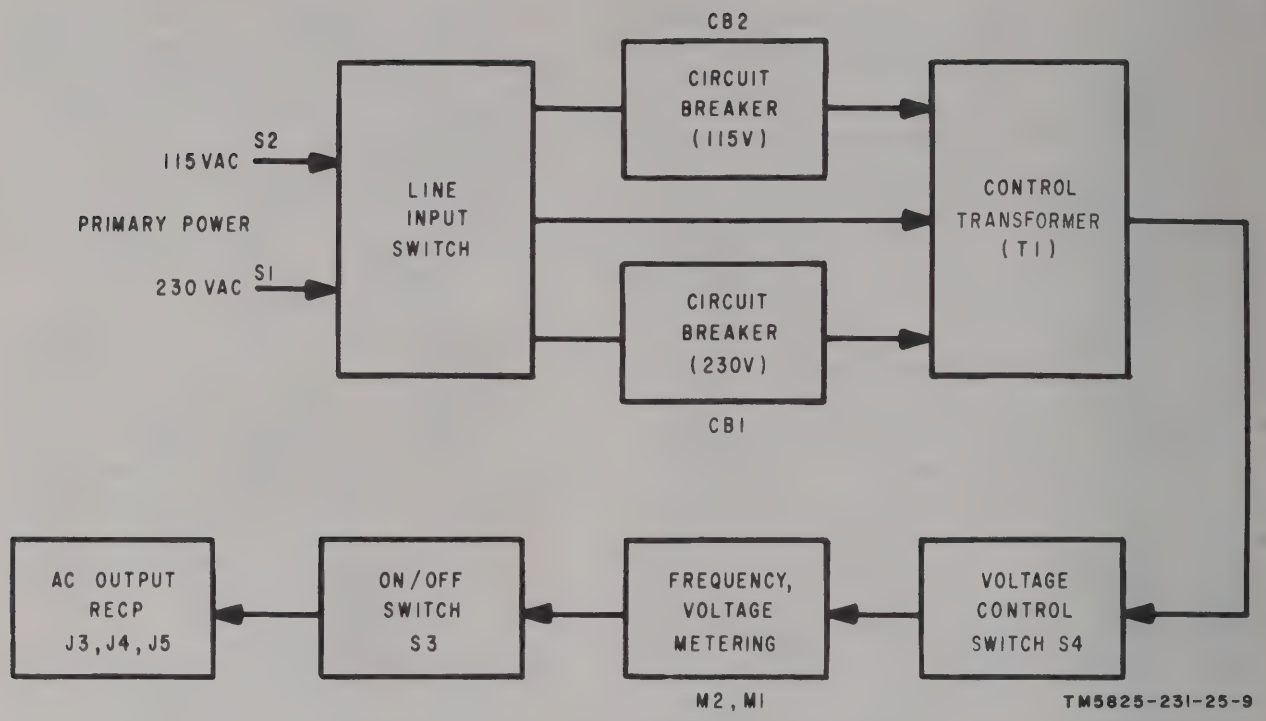

Figure 1–10. Power distribution panel, block diagram.

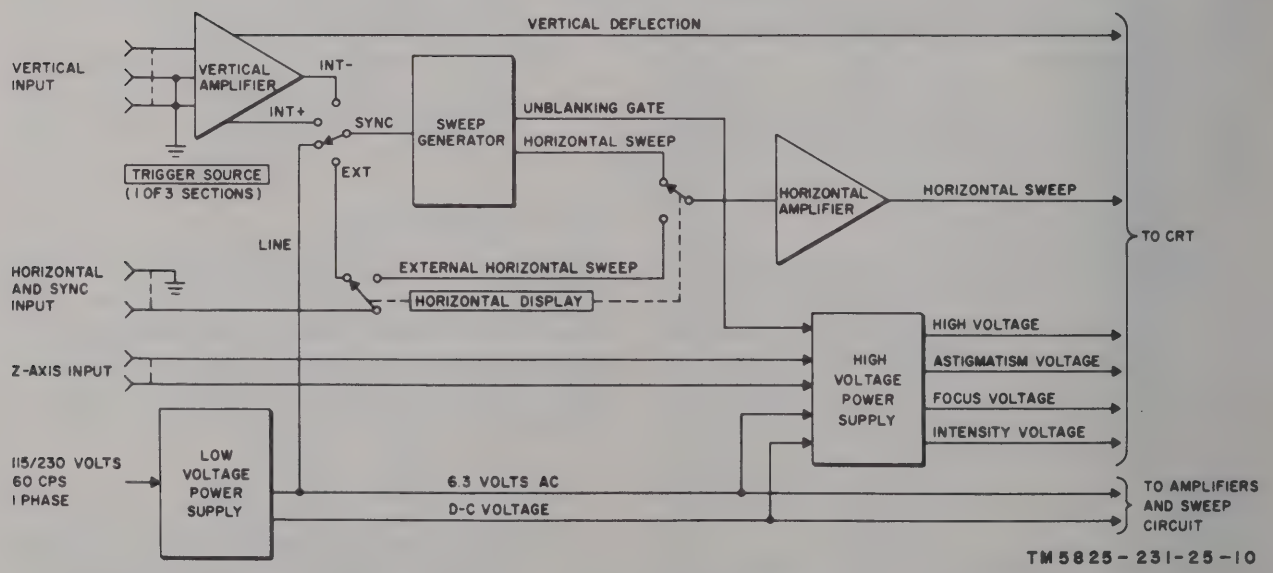

Figure 1–11. Oscilloscope, monitor block diagram.

circumference of the circle while the remaining one (monitor antenna) is situated near the center of the circle formed.

(2) The circuit arrangement of the twenty-five receiving antennas permits interception of wave fronts on a time sequence basis so that a line

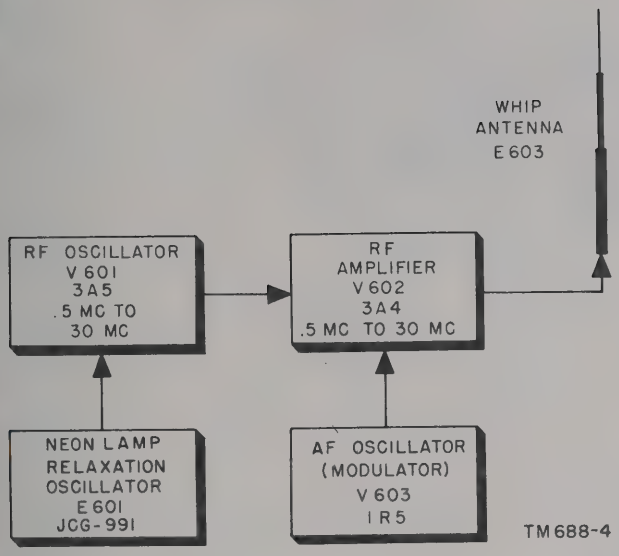

Figure 1–12. Radio Transmitter T–279A/UR, block diagram.

drawn from the center of the circle through the point of initial wave front interception along the circumference will intersect the transmitting source. In order to establish this point-of-entry, radiofrequency information is sampled from each antenna in sequence ninety times per second, resulting in a radiofrequency signal of definite phase relationship to the signal from the reference antenna and modulated by the rotational frequency of sampling. This signal is passed on the receiver and radio frequency detector where it is converted into transmission source intelligibility.

(3) The single antenna within the circular array is used for monitoring and reference purposes. As a monitor, it provides signals undisturbed by the rotational sampling process. As a reference, it provides a fixed (in time) signal source which may be related to the phase (time arrival) at any of the other receiving antennas.

(4) Each monopole exhibits the normal resonance and impedance characteristics of a thin wire antenna. The receiving pattern is essentially circular (omnidirectional) modified to some extent by the interaction of the remaining antennas in the array. Sensitivity of the system is dependent upon frequency and is maximum when the antennas are resonant (approximately 1/4 wavelength). A monopole without the loading section is resonant at approximately 10 megacycles. The addition of the loading section reduces resonance to approximately 6 megacycles. The lower section of each monopole contains a resistive impedance matching assembly terminating in a type "N" connector to match the characteristic impedance of the antenna to the transmission line. To effectively complete the transmission of signals to the rotary coupler, the antennas are connected through individual 100 foot lengths of RG/9U coaxial cable. All elements are matched to 50-ohms impedance to minimize interconnection losses at radiofrequencies.

(5) Each monopole is supported by three guy wires. Since the guy wires constitute antennas in themselves, special attention must be given to the continuously conductive length of each. Insulated separators are installed so that no continuously conductive wire is more than 1/4 wavelength of the highest frequency within the range of the system.

(6) Each monopole is equipped with a 10-foot square wire mesh installed beneath the base of the antenna and connected to the ground side of the antenna coupler (matching section). The wire mesh serves as an effective ground plane (counterpoise) for each antenna providing uniform ground conductivity.

b. Drive, Goniometer-Rotary Coupler (fig. 6–19). The drive, goniometer-rotary coupler is an assembly of functioning units which are driven by a synchronous motor. The motor ob-

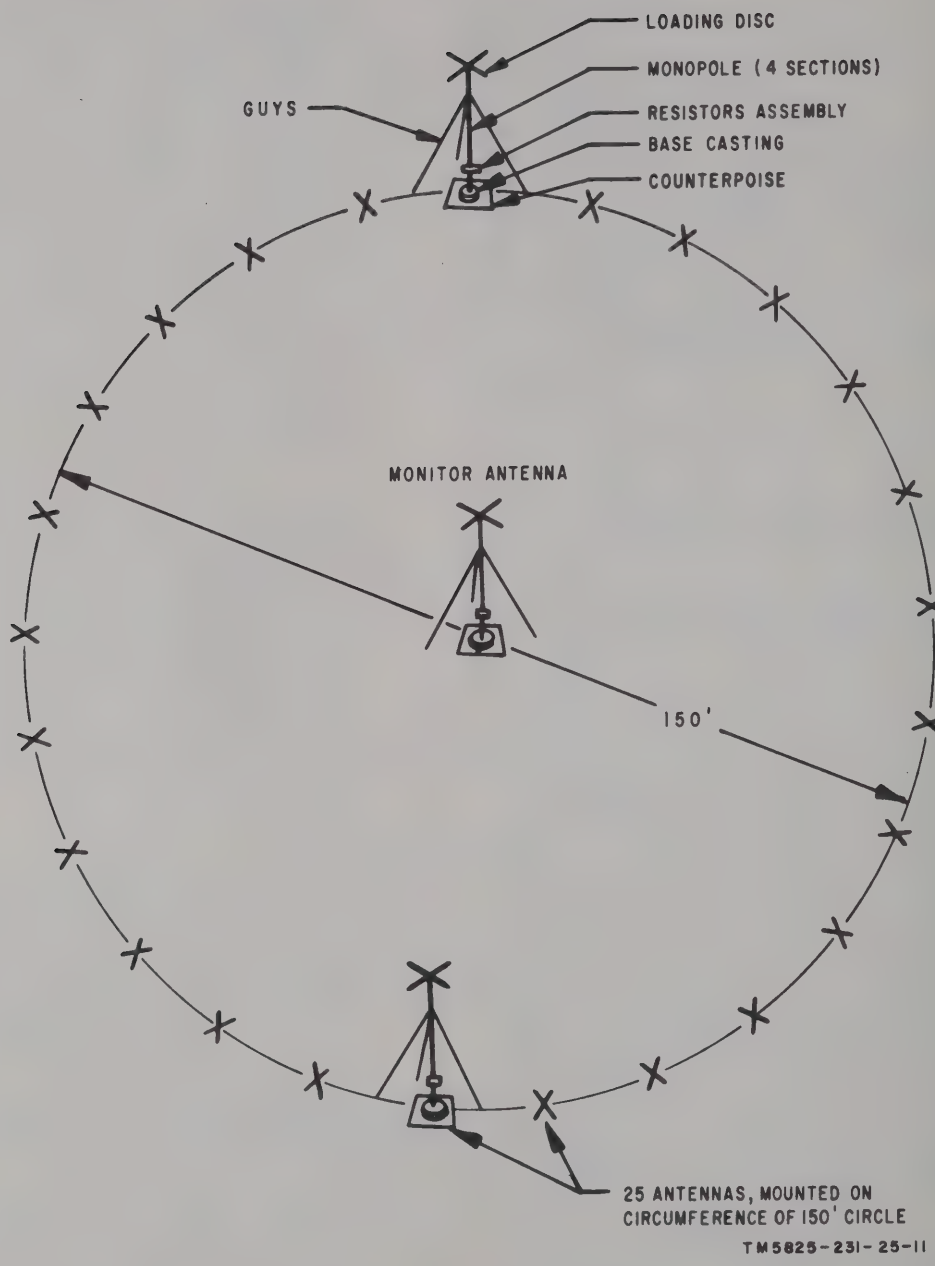

Figure 1–13. Antenna array diagram.

tains its power from a system-derived 180-cps power source and, in turn, drives, the—

Coupler, rotary RF,
Goniometer, primary,
Goniometer, Secondary, and
Sync voltage generator (magnetic pickup).

The chassis contains, in addition, relays and drive motor which are described in (5) and (6) below.

(1) *RF rotary Coupler* (fig. 1–14 and 6–3).

(*a*) The rotary coupler provides the necessary facility for sampling the radiofrequency energy from each of the twenty-five antennas in sequence and passing the resultant information on to the receiver for further processing.

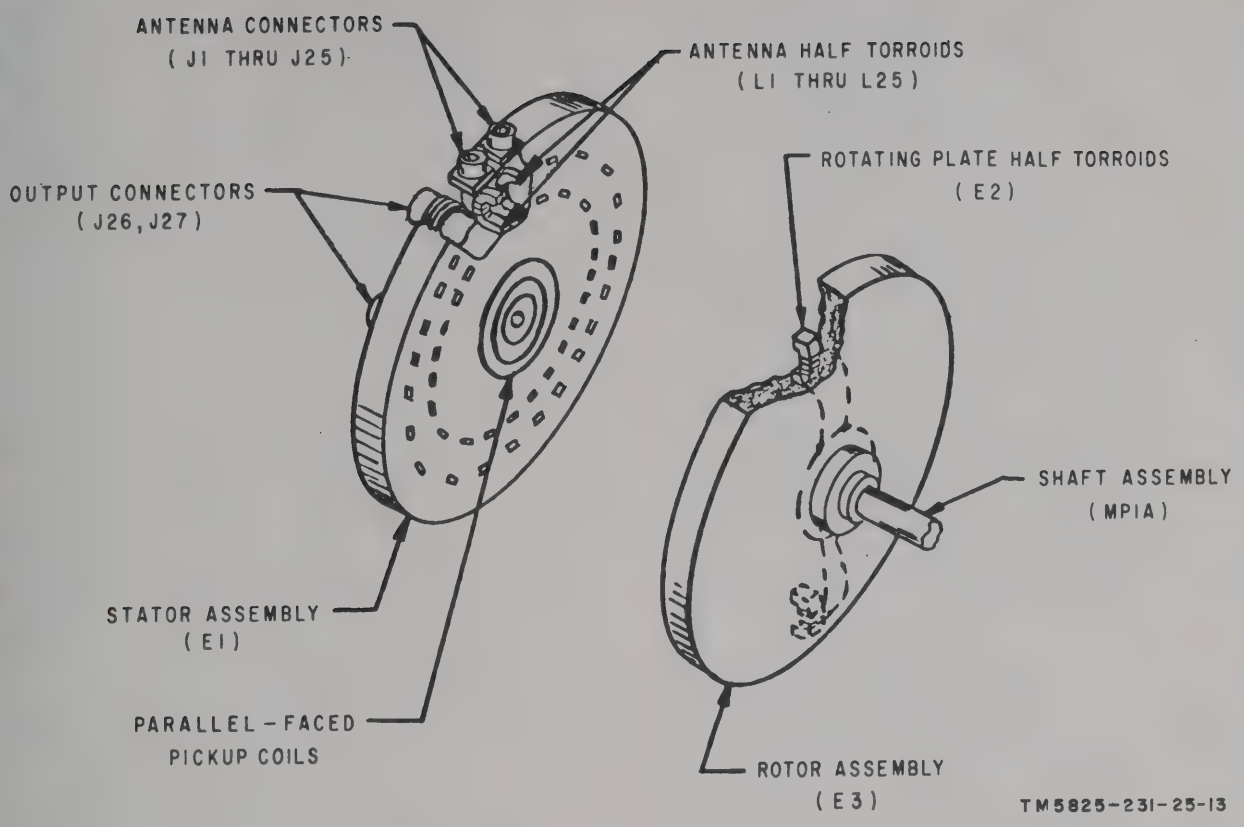

Figure 1-14. Rotary coupler, diagram.

(*b*) Each of the twenty-five antennas is connected sequentially to each of twenty-five transformer primary windings in the stator of the rotary coupler. The stator primaries are wound on half-torroid sections of ferrite core material spaced equidistant from each other and the perpendicular axis. The RF transformer is complete when a stator half-core is in perfect alignment with one of the two-mating cores spaced 180° apart on the rotor. The two windings on the secondary half-cores are connected to two coaxial windings on the rotor which are continuously coupled magnetically to two similar stationary output windings wired to output connectors.

(c) Radiofrequency signals from each of the twenty-five antennas appear at each of the twenty-five primary stator windings of the rotary coupler, and are coupled in turn to the 180° displaced secondary coils of the rotor. The smooth minimum to maximum coupling of primary and secondary windings results in an RF signal modulated by the frequency of rotation of the rotor, which is 90 cps. A second transformer action takes place when the outputs of the two rotor coils are connected to two coaxial primaries of output transformers. Continuous coaxial coupling takes place between the primary and secondary windings of the two output transformers so that outputs are extracted from this rotary device without the use of normally troublesome sliprings. The output secondaries are connected to

convenient connectors for signal routing to the system for additional processing.

(2) *Goniometer, primary* (fig. 6–4). The primary indicator goniometer is a rotary transformer which accepts, at the primary, a 72-kc sweep signal from the azimuth indicator and produces, across the secondary windings, two 72-kc signals displaced in phase 90° from each other. These signals are fed to the horizontal and vertical plates, respectively, of the indicator tube where they are displayed as a filled-in circle as the result of a radial sweep line. When df information is superimposed on the 72-kc signals the radial sweep is modulated to produce a half-propeller-shaped pointer. The rotation of the rotary coupler and the primary indicator goniometer are precisely synchronized so that a wave front passing over the antenna array from a given direction causes the pattern to point to precisely that direction.

(3) *Goniometer, secondary* (fig. 6–4). A second goniometer, identical to the primary goniometer functionally, is belt-driven from the primary goniometer. This unit is timed precisely with the rotary coupler to present accurate df display on the secondary indicator. The 72-kc sweep signal is derived from the secondary indicator unit and is processed in the second goniometer in the same manner as the primary unit.

(4) *Magnetic pickup* (fig. 6–19). Mechanically coupled to the secondary goniometer is a magnetic pickup device, PM1, which functions to provide a pulse for every revolution of the goniometer. This is accomplished by passing a magnet in close proximity to a pickup coil once every revolution. The magnetic lines of force cut by the turns of wire induce a voltage in the coil in the form of a steep-sided pulse. The excursion of the pulse is limited by diodes CR1 and CR2 while the final shaping of the pulse is determined by the differentiating network C1 and R1. The processed pulse is passed on via cable from J1 to the monitor oscilloscope to provide sweep synchronization with the rotary driven units.

(5) *Relay operation* (fig. 6–19).

(*a*) *Primary receiver relay.* Relays K1 and K2 permit the operator to select a received signal without direction finding information by shifting the input of the primary receiver to the monitor antenna. Direction finding information from the antenna array and RF coupler is normally fed through relay K1 to the balanced input of the primary receiver. When switch S3 on the azimuth indicator in the primary console is thrown to the MONITOR position, 6.3 vac is applied to J5. Rectifier CR3 and filter C4 provide a dc voltage for chatter-free operation of K1 and K2. When energized, K1 removes the RF coupler output from the balanced input of the receiver and K2 connects the output of the monitor antenna to the unbalanced input of the receiver. The output of the RF coupler enters the drive chassis via cable at J3, is optionally switched by K1, leaves at J4, and reaches the balanced input of the receiver via connecting cable. The output of the monitor antenna enters the chassis via cable at J6 and at the option of K2 leaves at J7 reaching the unbalanced input of the receiver by way of connecting cable.

(*b*) *Secondary receiver relay.* Relays K3 and K4 permit the operator to select a received signal without direction finding information by shifting the input of the secondary receiver to the monitor antenna. Direction finding information from the antenna array and RF coupler is normally fed through relay K3

to the balanced input of the secondary receiver. When switch S3 on the azimuth indicator in the secondary console is thrown to the MONITOR position, 6.3 vac is applied to J10. Rectifier CR4 and filter C5 provide a dc voltage for chatter-free operation of K3 and K4. When energized, K3 removes the RF coupler output from the balanced input of the receiver and K4 connects the output of the monitor antenna to the unbalanced input of the receiver. The output of the RF coupler enters the drive chassis via cable at J8, is optionally switched by K3, leaves at J9, and reaches the balanced input of the receiver via connecting cable. The output of the monitor antenna enters the chassis via cable at J11 and at the option of K4 leaves at J12 reaching the unbalanced input of the receiver by way of connecting cable.

(6) *Motor* (fig. 6–19). Motor B1 is a split-phase, synchronous-type requiring 115 volts at 180 cycles per second for operation. The power needed to drive the motor is supplied by the electronic control amplifier via cable to the input at J13. Capacitor C3 adjusts the overall power factor to a reasonable value while C2 provides the necessary 90° phase shift to enable the two-phase motor to operate from a single-phase source. The double ended shaft of the motor permits driving the rotary coupler and primary goniometer directly.

c. Amplifier, Electronic Control (fig. 6–20).

(1) This device provides the power necessary to drive the synchronous motor B1 described in (*b* (6)) above and shown in figure 1–9. This unit is a solid state amplifier consisting of controlling, voltage amplification, driver and power output stages energized by the self-contained dc power supply. A source of 115-volt, 60-cycle power is required for the supply via attachment connector J1.

(2) Line power is applied to power transformer T4 by way of ac power switch S1 and protecting fuse F1 rated at 8 amperes. Rectifiers CR8 and CR9, in a full-wave configuration, supply dc voltage for energizing the tuning fork and the stages of the amplifier after filtering by choke L1 and capacitors C10 and C11. Resistor R27 is a load resistance across the dc supply voltage. Transistor Q10 is a series voltage regulating element to maintain a constant dc voltage supply for the tuning fork, stages Q1, Q2, Q3 and the bases of Q4 and Q5. Resistor R18 establishes appropriate current flow for reference zener diode CR5 which provides a regulated base bias voltage for transistor Q10. Filtering of this voltage is accomplished by capacitor C5.

(3) DC voltage is fed to socket XMP1 at pins 7 and 6 (GRD) to energize the plug-in tuning fork MP1. Tuning fork output (180 cps) is taken at pins 9 and 6 and fed via coupling capacitor C1 to the base of the first emitter follower transistor Q1. From the arm of the divider R4 in the emitter of Q1, the output is limited by clipping diodes CR1 and CR2 before reaching the base of the second emitter follower Q3. Decoupling from the dc levels established by dividers R5, R6 and R10, R11 is accomplished by capacitors C2 and C3.

(4) The output (partially squared 180 cps voltage) from the emitter of the second stage Q3 is fed via coupling capacitor C4 to the primary of transformer T1 where coupling and waveshaping is provided for the push-pull input to the bases of Q4 and Q5. Resistor R17 provides the proper input impedance for the push-pull voltage amplifier stage Q4, Q5.

(5) Interstage transformer T2 provides coupling from the output (collector to collector) of Q4, Q5 to the input (base to base) of driver stage Q6, Q7. The collectors of driver stage are

direct coupled to the bases of the push-pull power output stage Q8, Q9 where sufficient 180 cps power is developed to drive the synchronous motor.

(6) The output transformer T3 provides the appropriate turns ratio and impedance to transform the power developed in the output stage to a voltage and current (115 volts at 1 ampere) to match the requirements of the motor load. Transformer T3 also serves to decouple the output from the dc supply voltage.

(7) Resistors R19 through R22 provide bias voltages for the driver and output stages while R23 and R24 limit the emitter current in the latter. Resistor R26 drops the 115 volts, 180 cps, when present, to illuminate the indicating neon lamp DS1. The amplifier is protected from loads in excess of 1 ampere by series connected fuse F2.

(8) Additional protection for the amplifier is provided by switching transistor Q2 which is held in a nonconducting state by a positive bias supplied by the tuning fork voltage. An overload in the output of the amplifier causes an increase in voltage drop across R25 which, when rectified by CR7 develops a negative voltage sufficient to override the positive bias and cause Q2 to conduct. The resultant low resistance from collector to emitter of Q2 effectively shorts out the 180-cps signal at a low load, high impedance source.

d. Radio Receiver (R–725/URR) (fig. 6 5).

(1) Signals intercepted by the circular antenna array are coupled by way of the RF coupler to the balanced input of the primary receiver. The tuned front end of the receiver selects the desired transmission and by multiple conversion reduces the signal to 455 kc modulated by the df information. This intermediate, modulated frequency is passed on to the RF detector unit for further processing before presentation on the face of the indicator.

(2) At the option of the operator, a secondary receiver performs in like manner to provide a second 455-kc modulated signal for integral processing in the RF detector. This two-receiver mode of operation is necessary when the transmission is other than AM, such as narrow band FM, PM or FSK.

(3) At the option of the operator a transmitted signal without df information may be fed directly into the unbalanced input of the primary receiver from the monitor antenna for monitoring or identification. In this mode of operation the signal is further processed in the receiver to be detected and amplified for aural (speaker) presentation.

(4) For detailed discussion and circuit analysis of the R–725/URR Radio Receiver, refer to TM 11–5820–358–35 which covers Radio Receiver R–390 A/URR. The information contained therein is unchanged except for the two items listed below.

(a) A hum-bucking circuit has been added to Radio Receiver R–390A/URR as shown in figure 6–5 to greatly improve its performance when processing direction finding information. Without this added circuit, the stability of the bearing presentation on the indicator is affected by 60-cycle (originating in the tube filament) modulation of the oscillator V701.

(b) The IF amplifier subchassis has been replaced in its entirety resulting in superior performance when used in conjunction with direction finding equipment. The description and circuit analysis of the amplifier follow.

e. IF Subchassis (part of Radio Receiver R 725/URR) (fig. 6–16).

(1) The IF subchassis contains six voltage-amplifier stages in addition to

detector, agc, bfo, limiter, and cathode follower stages. The desired bandwidth in the voltage-amplifier stages is obtained through the use of tuned circuits, as compared with the mechanical filters used in Radio Receiver R-390A/URR.

(2) The 455-kc output signal of the third mixer is applied to the grid of first IF amplifier V501 either directly or through crystal filter Z501, depending on the bandwidth desired. For the two narrow pass bands, .1 and 1 kc, the crystal filter is used. Four additional degrees of selectivity which do not use the crystal filter are accomplished in the IF stages by the BANDWIDTH switch which varies the coupling between the primary and secondary circuits of the IF transformers. The IF amplifier consists of six stages, V501 through V506, which, together with the associated transformers, provide the required pass band.

(3) The output of fifth IF amplifier V-505 is divided to supply a 455-kc signal to each of three stages: sixth IF amplifier V506, agc amplifier V509, and the cathode follower, one-half of V511. The output signal of the sixth IF amplifier is demodulated in the detector circuit, one-half of V507. An external load may be connected from DIODE LOAD terminal 14 and ground with the jumper between terminals 14 and 15 removed. The output of the fifth IF amplifier is amplified in agc amplifier V509, and the resulting signal is rectified by the agc rectifier, one-half of V510. When the FUNCTION switch is set for AGC operation, the gain of RF amplifier V201 and of IF amplifiers V501 and V505 is controlled automatically by a dc voltage developed by the agc rectifier, one-half of V510, to keep the output level of the receiver relatively constant and independent of signal strength variation at the antenna. Thus for strong signals, the grid bias is high and the gain of the controlled stages is reduced. The reverse action occurs for weak signals. The response rate of the agc circuits can be controlled to satisfy reception requirements through the use of the AGC switch, the agc time constant circuit, and one-half of tube V511. For MGC operation, the agc bus is grounded by the FUNCTION switch. The cathode follower, one-half of V511, provides a low impedance connection (50 ohms) from the output of the fifth IF stage for use when the receiver, is employed for frequency-shift teletypewriter and single sideband reception.

(4) To facilitate operation in the reception of radiotelegraph signals, in certain system applications and in calibration, bfo tube V508 provides a signal in the frequency range of 452 to 458 kc. This signal is mixed with the 455-kc IF output signal of the sixth IF amplifier to produce a beat frequency in the output of the detector which is in the af range.

(5) The output of the detector (one-half of V507) is coupled to the af amplifier (V601A) through a negative peak limiter (one-half of V507) and a positive peak limiter (one-half of V510) which prevents noise peaks from exceeding average signal level. If operation without limiting is desired, the limiters can be disabled by a front panel control.

(6) In addition to supplying signals to the limiter, the detector, one-half of V507, supplies a dc signal to the squelch tube, V606, which is a voltage amplifier. The average dc output voltage of the squelch tube varies in proportion to the average signal level. When the signal level drops below some predetermined noise level established by the setting of the RF GAIN control and when the FUNCTION switch is set for SQUELCH

operation, this voltage operates squelch relay K602, which short circuits the output of af amplifier V-601B to quiet the receiver output.

f. Detector, RF (RF–159/TRD) (fig. 6–18).

(1) The RF detector is a device designed to examine a received signal, remove any amplitude modulation present in the received signal, and convert remaining phase modulation into audio frequencies. The phase modulation component resulting from system processing contains the desired DF information. Hence, the presence of PM or FM on a received carrier is undesireable for direct processing and subsequent conversion to a DF display. It is necessary, therefore, to remove any unwanted (interfering) PM or FM prior to conversion to the required DF display.

(2) The signal being received on the first receiver may be tuned in on the second receiver using an antenna that gives no DF information (monitor antenna). Then, if the IF of the first receiver (containing DF and interfering information) is beat down to a lower frequency and the IF of the second receiver (presenting only interference) is similarly beat down to a frequency not quite so low, the difference between the two may be used as a new IF.

(3) This new IF presents none of the station-produced FM or PM because the difference between the two "beat-down" frequencies always remains the same provided the beating devices used to shift the receiver IF's do not change. To facilitate operation, provision is made to replace the IF of the second receiver (the one not receiving DF information) with a crystal-controlled oscillator when the receiver carrier does not contain FM or PM.

(4) The IF output of the primary receiver, 455 kc, is amplified in V7 and then limited in V8, V9, V10. The output of V10 is applied to the control grid of V11, a pentagrid converter with a crystal controlling its frequency of oscillation to 550 kc. The plate of this stage is tuned to a difference frequency of 95 kc.

(5) The 95-kc signal derived from V11 is applied to the cathode of V12A, mixer section. The grid of V12A is excited by a signal derived from the secondary receiver channel. This channel has as its source either the IF of the secondary receiver or the output of crystal oscillator stage V1 as determined by the operation of relay K1, an operator-controlled function.

(6) The signal selected by the operator is amplified by V2, limited by V3, V4, V5, and the output of V5 is applied to the control grid of V6, a pentagrid converter tube with a crystal-controlled frequency of 555 kc.

(7) The plate output of V6 is tuned to the difference frequency of 100 kc and it is this frequency which is used to excite the grid of V12A.

(8) The untuned output of V12A is now impressed on the grid of V12B, the cathode follower section, and is used to feed FL1 from a low impedance source. Low pass filter FL1 selects the 5-kc signal from the mixer products generated in V12A, and the 5-kc frequency now becomes the operating frequency.

(9) The filtered 5-kc signal is amplified by V13 and limited in V14 and V15, cathode-coupled limiters, to remove any incidental AM produced in the previous processing.

(10) The PM detector, (pulse count type) consisting of C72, CR1, CR2, R83 and C74 receives the limited 5-kc signal and demodulates it. In this system the recovered, demodulated signal is 90 cps.

(11) The RC networks following the detector reduce the amplitude of the carrier level present with the demodulated signal. This produces an ap-

parent smoothing of the detected wave shape.

(12) The filtered signal is further amplified by V17 and then its second, third and fourth harmonics further filtered out. Inductors L11, L12, and L13, with their associated capacitors, resistors, and potentiometers form null networks. When properly adjusted these networks filter out the fourth, third, and second harmonics, respectively.

(13) The filtered signal is amplified in V18 section one. Section two of V18 is used to provide a low impedance output for the indicator and associated equipment.

(14) The auxiliary output portion of the circuitry is not used in this system but is described as follows: In parallel with the output is the primary of T2. The secondary of this transformer is resistively center tapped. Diodes CR4 and CR6 form a balanced full-wave rectifier used to rectify the balanced-to-ground signal present on the secondary of T2. The rectifier output is connected to an auxiliary output.

g. RF Detector Power Supply (fig. 6–15).

(1) The power supply receives controlled primary power from the power distribution panel described in paragraph 1–8. To protect against overloads, a fuse is included in the ac input circuit. The ac input circuit also includes a switch to permit turning the unit on or off.

(2) The power transformer T1 steps up the line voltage to high voltage for the B+ supply rectifier tube. In addition to the high voltage winding, transformer T1 has two filament windings. One supplies filament voltage for the rectifier and the other supplies all remaining tube filaments in the power supply and detector.

(3) Full-wave rectifier tube V1 allows alternate half cycles of the current from the transformer high voltage winding to pass on to the smoothing section R1, C1. The pulsating current out of V1 is smoothed out by the alternate charging and discharging of C1 thru R1.

(4) The smoothed current, which is DC, is passed through a series regulator tube V2.

(5) The regulator tube depends on the grid-to-cathode voltage, grid bias, to change the current flowing through it. The grid bias voltage is developed by taking a portion of the output voltage and comparing it to the reference voltage established by V4.

(6) DC amplifier V3 multiplies (amplifies) this voltage difference and impresses it on the control grids of V2 causing the tube to change its conductivity and this in turn causes a change in output voltage.

(7) Hum balance control R2 takes a small amount of the hum present at the output R1–C1 and applies it to DC amplifier V3 in such a manner that it bucks out any hum that might find its way through V2, the series regulator tube.

(8) Voltage control R13 adjusts the bias on amplifier V3 which determines V2 conductivity and the output voltage as stated in paragraph 1–6.

h. Indicator, Azimuth (IP 669/TRD) (fig. 6–17).

(1) The azimuth Indicator receives a signal from the RF detector, references it to information from the goniometer drive and presents the information half-propeller as a visual display.

(2) The azimuth indicator is essentially a phase measuring device which displays, on a cathode ray tube, the angular phase relationship of two 90-cps signals. The first of these is the basic reference signal, equivalent to the 90-cps rotation of the goniometer drive system. The second 90-cps signal is the df data signal, whose phase angle relative to the reference signal, is proportional to the azimuth angle of arrival of the RF wave

front. By measuring this phase difference and displaying it in the form of a propeller pattern on the face of the cathode ray tube, a visual indication of direction is achieved.

(3) The basic reference signal is displayed on the cathode ray tube as a rotating strobe line, which, due to its speed of rotation, appears as a filled-in circular pattern (in the absence of df signal). The rotation of the strobe line is derived from the goniometer coupled to the motor shaft and is therefore angular coincident to the basic reference signal. The strobe line is developed by a 72-kc sweep signal to the horizontal and vertical plates of the cathode ray tube. The 72-kc sweep signal is routed to the horizontal and vertical axis of the catode ray tube through the goniometer. The goniometer is basically a rotating transformer which modulates the output as a function of angle between primary (rotor) and secondary (stator). Two stator windings are physically displaced by 90°, therefore the peaks of the modulated envelope occur 90° apart on one stator with respect to the second stator. The outputs of these two stators are connected to the horizontal and vertical plates of the cathode ray tube respectively. Rotation of the goniometer causes coincident rotation of the strobe line on the cathode ray tube and produces a circular pattern synchronous with goniometer rotation. At any given instant of rotation, the angle indicated by the strobe line is coincident with the angular position of the commutator and signal goniometer. As previously stated, the phase of the df data signal relative to the reference signal is dependent upon angle of arrival of the RF wave front relative to the position of the motor shaft. If the df data signal is now used to modulate the indicator sweep signal prior to goniometer input, a given point of reference on that data signal will appear on the indicator circular pattern at an angle of rotation equivalent to the phase difference between the reference signal and the data signal, to produce the propeller-shaped pattern.

(4) DF information received at J1, from the RF detector unit, is applied to the grid of amplifier tube V1A via DF GAIN potentiometer R1 and coupling capacitor C1. The signal is amplified in V1A and fed through a cathode follower V1B and isolating transformer T1 to the full wave rectifiers CR1 and CR2. This full-wave rectification produces a negative-going pulsating voltage of 180 cps which is applied to the control grid of the control modulator V2.

(5) A 72-kc voltage is generated in oscillator V5 and frequency controlled by crystal Y1. Peaking is accomplished by adjustable inductance L1 and coupling from the cathode of V5B is provided via capacitor C16 and SIZE control R33.

(6) The output of control tube V2 is varied by the amplitude of the pulsating signal. The output is maximum when the pulsations reach the zero voltage level and minimum when the pulsation goes greatly negative. This process of control produces a signal of 72-kc carrier modulated at 180 cps. The signal is peaked in transformers T2 and T3 and amplified in V3, finally appearing at the 72-kc OUTPUT jack J2.

(7) The carrier thus produced is applied to the rotating winding of the goniometer unit and due to the mechanical arrangement of pickup coils, a two-phase signal is obtained at its output. One of these phases is connected to T4 and the other is connected to T5. One phase from J3, J4 is shaped by SHAPE control R17 and peaked in transformer T4. The isolated secondary of T4 provides coupling to the horizontal deflection plates of the

cathode ray indicator tube V4. The other phase from J5, J6 is peaked in transformer T5 and fed to the vertical deflection plates of V4.

(8) Horizontal and vertical dc centering voltages are also applied to transformers T4 and T5. These voltages are obtained from the high voltage power supply via H control R48 and V control R49 to permit accurate positioning of the bearing indication on the indicator V4.

(9) Since the goniometer unit is rotating at 90 rps, its two-phase output signal produces a sweep pattern on the indicator tube V4 rotation at the same rate.

(10) Control tube V2 is supplying a recurring signal at a rate of 180 cps. Therefore, two indications will be seen on the indicator tube for each revolution. One of these is the desired bearing and 180° from it is the undesired or reciprocal bearing. The reciprocal bearing is subsequently blanked out by the sense circuits by processing a portion of the original 90 cps DF signal.

(11) A portion of the 90 cps df signal, taken at the cathode of V1B is peak clipped by diodes CR3 and CR4, then amplified by triode amplifier V6B. The flattened sine wave is coupled through capacitor C19 and transformer T6 to a balanced modulator consisting of diodes CR5 and CR6. The other signal required for proper operation of the modulator is a 72-kc frequency from oscillator V5 taken at the cathode of cathode follower V6A and fed via C16 and C21 to the junction of R40, R41. Balance is achieved by adjustable inductor T7 before the signal is passed on via C23 to the grid of V7 for further amplification. Capacitor C26 provides the necessary isolation from the high dc voltage appearing on the intensity grid of V4.

(12) The output from the modulator, a carrier suppressed signal bearing 180 cps modulation, is clipped to suppression in one direction by CR7. This clipped signal is applied via C26 to the intensity grid of the indicator tube. Phase is controlled such that it cuts off the indicator tube when the reciprocal bearing is being presented.

(13) The high voltage required by the indicator tube, is supplied by a conventional voltage doubler. Transformer T9 supplies the ac high voltage while R75 and R76 are peak current limiting resistors. Diodes CR8 and CR9 are used as rectifiers and capacitors C34 and C35 are used as storage-filter devices. R51 through R60, R83 through R85 are voltage divider resistors. R57 and R60 are variable to provide adjustable voltages to the FOCUS and INTENSITY grids of the indicator V4.

(14) The low voltage power supply, using tubes V8, V9, V10, V11 for rectification, series regulation, amplification and reference, is similar to that used in the RF detector power supply described in *g* above.

(15) Four lamps, energized by one of the filament 6.3-vac windings of the transformer T8, illuminate the numerals of the indicator allidade. A DIMMER control R74 regulates the intensity desired by the operator.

(16) When the MON–DF switch is set to the MON position, a resistor R86 is placed in series with the primary of high voltage power supply transformer T9. This reduces the intensity and shorts the DF signal at the input of the indicator. An operator is thus enabled to listen to a received signal and have no indication on the indicator tube.

i. Oscilloscope Monitor.

(1) *Vertical amplifier* (fig. 6–23).

(a) For ac coupling, capacitor C1 is placed in series with the signal path by means of the AC–DC switch. The input signal is then applied to VERTICAL SENSITIVITY switch S2. When the switch is

in the CAL position, the input of the amplifier is directly connected to the output of the calibrator (V-4, V5 and associated circuit parts). When the VERTICAL SENSITIVITY switch is in other positions, precision frequency adjusted attenuators are inserted. These attenuators give a ten-to-one attenuation between adjacent positions. The input signal is then applied to the control grid of amplifier V1A.

(*b*) Balanced input to differential amplifier V1B is obtained by removing the ground jumper across resistor R1 (ground strap on front panel) and applying a balanced signal input. Balanced input is useful in applications where it is desired to simultaneously amplify the out-of-phase (differential) signal and attenuate the in-phase (common mode) signals, such as hum, noise, etc. This rejection is an inherent property of differential amplifiers. The common-mode signals are attenuated by 40 db (100:1), whereas any differential input is amplified.

(*c*) The vertical amplifier consists of three sets of balanced differential amplifiers (V1, V2, and V3) in cascade. The three stages are neutralized by plate-to-grid cross neutralization. The first stage, V1, has balance and gain adjustments. The balance adjustment (BAL) is potentiometer R16 in the cathode circuit, which adjusts the current distribution between the two triodes. Potentiomenters R21 (VERNIER control) and R20 (CAL) adjust the resistance between the plates and therefore determine the gain of the amplifier. The VERTICAL VERNIER control provides a ten-to-one variation in gain between ranges of the VERTICAL SENSITIVITY switch. The second differential amplifier, V2 has potentiometer R32 (vertical POSITION control) between its cathodes. This potentiometer controls the current distribution between the two triodes and thus determines the vertical position of the CRT display. The third differential, amplifier, V3, is the output stage. Synchronization signals are taken from the plates of V3 for application to the TRIGGER SOURCE switch. Since the horizontal sweep circuits trigger only on the negative slope of the signal, provision is made to take the proper synchronizing signal from either plate of V3.

(*d*) One section of the BEAM FINDER switch is in the cathode circuit of V3. When pressed, the switch increases the common cathode resistance and so reduces the gain of the stage that no amount of unbalance ahead of V3 can deflect the sweep off the CRT.

(*e*) The calibrator circuit consists of neon lamps V4, V5, and associated circuit parts. When VERTICAL SENSITIVITY switch S2 is placed in the CAL position, V4 ionizes and capacitor C14 begins charging. As the voltage across capacitor C14 rises, the voltage at the junction of V4 and R52 rises proprotionally. When the voltage at this junction reaches the firing potential of V5, V5 ionizes. Since the conducting potential of V5 is less than the firing potential, the voltage at the junction of V4 and V5 drops, and V4 de-ionizes. C14 discharges through R53, and the potential across V4 increases. When the potential across V4 reaches the firing potential, V4 fires and the voltage at the junction of V4 and V5 drops, deionizing V5. C14 starts charging again, and the cycle repeats. A 60-mv square wave is developed across R54, and this signal is applied through the SENSITIVITY switch to the vertical amplifier.

(2) *Sweep generator* (fig. 6–22).

(*a*) The sync signal from the TRIGGER SOURCE switch is applied to trigger generator V201. The trigger generator produces a rectangular wave with a repetition frequency equal to that of the input sync signal. This rectangular wave is applied to a differentiating network which converts it to positive and negative spikes that are coincident with the leading and trailing edges of the rectangular wave. These spikes are then applied to the input of start-stop trigger V-202.

(*b*) The negative spike switches the start-stop trigger, which produces two step outputs. The positive-going output is applied through V204 to the high voltage power supply as the crt unblanking gate, and the negative-going output is applied to switch diode CR201.

(*c*) Switch diode CR201 normally clamps the input to sawtooth integrator V205A to a low negative voltage, preventing sawtooth integrator V205A from generating a sawtooth waveform. When the negative-going step signal from the start-stop trigger is applied to the switch diode, however, the diode is reverse biased and allows the sawtooth integrator to generate a sawtooth waveform.

(*d*) The sawtooth output of V205B is simultantously applied to the horizontal amplifier to serve as the horizontal sweep signal and the holdoff cathode follower V203B. The output of the holdoff cathode follower is applied to the input of the start-stop trigger to terminate the sweep. The values of R and C selected by the HORIZONTAL DISPLAY switch determines the slope of the sweep and therefore the time of the sweep. Clamp V204 insures that the sawtooth always starts at the same level.

(*e*) *Trigger generator V201.* The sync signal selected by the TRIGGER SOURCE switch is applied through capacitor C202 and resistor R201 to the input control grid of V201, which is a Schmitt trigger circuit when the TRIGGER LEVEL control is not in AUTO. The Schmitt trigger is a form of bistable multivibrator, and is used to obtain pulses with rapid rise and fall times.

(*f*) If initially the input voltage is such that V1 is cut off, V2 conducts. As the input voltage becomes more positive, it eventually reaches a predetermined level at which the circuit changes state; that is, V1 conducts and V2 is cut off. If the input voltage then goes negative, the common cathode potential decreases and the grid of V2 becomes positive. When the input reaches a second predetermined level, V2 conducts and the circuit switches back to its initial state. The output of the circuit is a voltage step, either positive or negative depending upon the slope of the input signal.

(*g*) The input voltage levels at which a Schmitt trigger circuit switches are called the hysteresis limits.

(*h*) Trigger generator V201 has some additional features: the TRIGGER LEVEL control adjusts the bias on V201A and thus determines the level which the input trigger must reach to change state; in addition, when the TRIGGER LEVEL control is at its extreme limit, switch S202 is placed in AUTO. This opens the shunt across resistor R-207 and capacitors C205 and C206 and the trigger generator becomes an astable multivibrator. This provides triggers to the stop-start trigger even though no sync is applied to the trigger generator. When a sync signal above approxi-

mately 50 cps is applied, however, the trigger generator then synchronizes with the sync signal. The step output of the trigger generator is taken from the plate of V201-b and applied to a defferentiating network.

(*i*) Differentiating Network. The differentiating network is composed of the series combination of capacitor C207, inductor L201, and resistor R210. The r–c time constant of this network is extremely small compared with the width of the trigger generator output pulses; consequently, the signal developed across inductor L201 and resistor R210 consists of short negative and positive spikes that are coincident with the leading and trailing edges of the trigger generator output pulses. These spikes are coupled through capacitor C208 to the control grid of V-202A, one half of the start-stop trigger.

(*j*) Start–stop trigger V202 clamp V-203A, and switch diode CR201. The start–stop trigger is a Schmitt trigger circuit. A typical Schmitt trigger is described in (*f*) above, V202 is triggered by a negative spike pulse from the diffferentiating network. One output step waveform is taken from the plate of V202B and simultaneously applied to switch diode CR201 and the grid of clamp V203A. The waveform applied to V203A cuts off V203A, and thus disables the clamping action of this tube. The waveform applied to switch diode CR201 reverse-biases the diode, and thus it ceases conduction. Another step output is takn from the plate of V202A and applied through cathode follower V203A to the high voltage power supply; this serves as the crt unblanking gage.

(*k*) Sawtooth generator V205A and sawtooth cathode follower V205B. Sawtooth generator V205A, is a Miller integrator which produces a linear sawtooth waveform. When switch diode CR201 ceases conduction, the integrating capacitor charges through the integrating resistance, producing a negative-going potential at the control grid of V205A. The amplified signal at the plate of V205A is coupled back through sawtooth cathode follower V205B to the integrating capacitor, completing the negative feedback required by this Miller type integrator.

(*l*) The sawtooth signal at the cathode of V205B is also applied to SWEEP MAGNIFIER switch S102. When S102 is in the X5 position, the saw tooth applied to the horizontal amplifier has a peak amplitude five times greater than that applied when S102 is in the X1 position; hence, the angle of slope is increased five times and the sweep time is one-fifth of that selected by the HORIZONTAL DISPLAY switch.

(*m*) The sawtooth signal at the cathode of V203B is applied to the control grid of V202A. When the slope of the signal reaches the upper hysteresis limit of the start-stop trigger, the trigger changes state; hence, the unblanking gate output of V203A is terminated. The switch diode CR201 and clamp V-204 again conduct, respectively, halting the charging of the integrating capacitor and terminating the sawtooth waveform. The holdoff capacitor in the cathode of V-203B charges during the rising slope of the signal output of the holdoff cathode follower but does not immediately discharge when the sawooth input to the holdoff cathode follower terminates. This

prevents the start–stop trigger from again being triggered by a negative spike until the sweep circuits have fully recovered. A different value of holdoff capacity is selected for each setting of the HORIZONTAL DISPLAY switch.

(3) *Horizontal amplifier* (fig. 6–21).

(*a*) The grid of V101A (fig. 6–1) receives either the sweep output from the horizontal sweep circuits or from an external sweep source, depending on the setting of the HORIZONTAL DISPLAY switch. When external sweep is being used (EXT SENSITIVITY positions), any one of three horizontal sweep sensitivities can be selected: .1 VOLTS/CM, 1 VOLTS/CM, or VOLTS/CM. The AC–DC switch allows selection of direct coupling, or ac coupling through capacitor C101.

(*b*) The horizontal amplifier consists of two differential amplifiers (V-101 and V102) in cascade. When the HORIZONTAL DISPLAY switch is set to one of the EXT SENSITIVITY positions, the resistance between the cathodes of amplifier V101 consists of the horizontal VERNIER control (R275B) in series with the horizontal gain control (R104); otherwise, resistor R107 is between the cathodes. The horizontal POSITION control (potentiometer R109) between the plates of V101 controls the horizontal position of the CRT trace. The second stage (V102) is neutralized by plate-to-grid cross neutralization. The output of the horizontal amplifier is taken from the plates of V102 and applied directly to the horizontal deflection plates of the crt.

(*c*) One section of the BEAM FINDER switch is in the cathode circuit of V102. When pressed, the switch increases the common cathode resistance and so reduces the gain of the stage that no amount of unbalance ahead of V102 can deflect the sweep off the CRT.

(4) *Low voltage power supply* (fig. 6–24).

(a) The 115/230-volt, single-phase power is applied through switch S301 to transformer T302. The transformer applies 6.3 volts ac to the vertical amplifier, horizontal amplifier, sweep generator, and high voltage power supply for use as filament voltage; the transformer also applies appropriate ac voltages to the following: the +19-volt dc regualted power supply; the +300, +100-, and +99-volt dc regulated power supply; and the –150-volt dc regulated power supply.

(*b*) The regulated power supplies deliver their dc outputs to the following circuits: +19 volts dc is applied to the horizontal and vertical amplifiers; and +19, +100, +300 and –150 volts ac are applied to the vertical amplifier, the horizontal amplifier, the horizontal sweep circuits, and the high voltage power supply; in addition, the –150-volt supply applies a negative voltage to the +19-, +99-, +100-, and +300-volt supplies for use as a control voltage.

(*c*) –150-Volt dc regulated power supply. The –150-volt supply in the 120B is used as a reference supply for the +300-, +100-, and +99-volt supplies; therefore, any change in the –150-volt supply is reflected as a change in these supply voltages. The ac voltage from T302 is rectified and partially filtered by rectifier CR303 and capacitor C325A. The resulting dc voltage is regulated and further by tubes V309, V-310, and V311.

(*d*) The circuit functions as follows: When power is applied (assuming the –150-volt supply has been adjusted properly) the cathode of V-310 becomes fixed at –65 volts and the grid assumes a slightly more negative value. If a line voltage surge or load current change were to occur, tending to lower the supply voltage, V310 grid potential would tend to change by half the amount, since the grid is tied to a voltage divider between –150 volts and ground. The result is increased bias for V310, lowering its current, raising its plate voltage, which, in turn, lowers the bias on V309. This bias change in V309 lowers its resistance, decreasing the voltage drop across this element which tends to return the supply voltage to its original value.

(*e*) +300-, +100- and +99-Volt dc regulated power supply. The +300-volt supply operates in almost the same manner as the 150-volt supply except that it uses the –150-volt supply as its voltage reference. In this supply, CR301, CR302, V-307, and V308 are the rectifier, series regulator, and amplifier, respectively. The +100- and +99-volt supply is further regulated by V308B, referenced to the +300-volt supply.

(*f*) +19-volt dc regulated power supply. The +19-volt supply (for the filaments of vertical amplifiers V1 and V2) uses rectifier CR304 and capacitor C328 for rectifier and filter. Transistor Q301 is a series regulator using the potential across zener diode CR302 for its voltage reference. The current in transistor Q301 determines the value of the dc voltage across the filaments.

(5) *High voltage power supply* (fig. 6–25).

(*a*) Oscillator V302 generates an ac voltage and applies it to step-up transformer T301. The stepped-up ac voltage is applied to rectifiers V303 and V304. The negative high voltage output of V303 is applied to the cathode of the CRT, and the negative high voltage output of V304 is applied to the control grid of the CRT. The difference between the two voltages is the CRT bias and thus controls the CRT intensity.

(*b*) When the INTENSITY control setting is changed, a change occurs in the cathode high voltage, causing a change in the voltage level at the wiper of the –2500-volt adjust potentiometer. This results in regulator V301 altering the control voltage in a direction necessary to return the cathode high voltage to its original value; however, this now results in the control grid high voltage being higher or lower than previously and thus the CRT intensity is altered.

(*c*) High voltage rectifier V303. The ac high voltage present in one secondary winding of T301 is rectified by V303 and filtered by capacitor C308. A portion of the +100 volts dc taken from the wiper of INTENSITY potentiometer R321 is effectively in series with and opposing the high voltage output of V303. When the BEAM FINDER pushbutton is depressed, the opposing voltage from the wiper of potentiometer R321 is effectively removed and the intensity of the CRT trace is increased.

(*d*) When a signal is applied to the Z AXIS input, the signal is applied through capacitor C307 to the cathode of the crt and thus modulates the CRT intensity.

(*e*) A voltage divider network, consisting of resistors R313, R311, R-310, R309, R307, potentiometers

R312 (FOCUS control) and R308 (–2500 adjust), is tied between + 300 volts dc and the cathode of the CRT. The voltage present at the wiper of R312 is applied to the crt focusing grid as focusing voltage, and the voltage present at the wiper of R308 is applied to amplifier V301B as the high voltage control voltage.

(*f*) Amplifier V301. When a change in the value of the high voltage occurs, a corresponding change occurs at the wiper of potentiometer R308. This alters the bias at the grid of V301B, and the resultant change in the plate voltage is dc coupled through R305 to the control grid of V301A. This, in turn, results in a change in the plate voltage of V301A, which is connected to the screen grid of oscillator V302. The overall effect is that when the high voltage decreases, the screen grid voltage of V302 increases to a point where the increased ac output of V302 restores the high voltage to its original value.

(*g*) High voltage rectifier V304. The ac high voltage across the other secondary of transformer T301 is rectified by V304 and filtered by capacitor C310. The negative side of the high voltage is applied through resistor R327 to the control grid of the CRT. The positive side of the high voltage is applied through resistor R326 to the horiontal sweep circuits, wherein the unblanking gate is generated. When the positive-going unblanking gate is generated, the CRT control grid bias becomes less negative and the CRT is unblanked.

j. Radio Transmitter (T–279A/UR) (fig. 6–7).

(1) The Radio Transmitter T–279A/UR contains in one compact case the self-powered circuitry necessary to transmit a test signal from a precisely known source (within 1 mile) to check the operation and calibration of a direction finder set. The circuitry falls into four major groups for purposes of discussion. They are the RF oscillator, the RF amplifier, the AF oscillator, and the neon lamp relaxation oscillator.

(2) RF Oscillator V601.

(*a*) The RF oscillator stage utilizes a triode connected type 3A5 tube in a conventional series fed Hartley oscillator circuit. The circuit is designed to operate on any frequency within the range of .5 to 30 megacycles. This range is divided into six bands, any one of which may be selected by the BAND SWITCH, S603. BAND SWITCH S603 connects one of six tapped coils (L601 to L606) into the oscillator tuned circuit. Trimmer capacitor C602, is used to vary the capacitance of the oscillator tuned circuit and thus the frequency so that it will "track" correctly with the RF amplifier stage.

(*b*) Since the circuit does not permit grounding either end of the coils, two switch sections 2 and 3, must be used. Each switch section has a shorting bar which places all but the active coil at ac ground (but at +90 volts dc) to minimize energy absorption by the unused coils.

(*c*) The circuit oscillates because a voltage 180° out of phase with the plate voltage is obtained from the grid end of the tuned circuit. This voltage, which is of the proper phase and magnitude to sustain oscillation, is fed back to the grid through capacitor C603. Grid current flowing on positive alternations charges C603 through the low grid-to-cathode-resistance of V-601. Only a small portion of this

charge is allowed to leak off on negative alternations since R601 presents a relatively large discharge path. After several cycles a residual charge is accumulated on C603 which is effectively a negative bias between the grid and the cathode. Capacitor C604, C615 and coil L-613 form a decoupling filter at the oscillator frequency and isolate this stage from the B+ supply in order to prevent interaction with other circuits. Capacitor C607 couples the RF oscillator output to RF amplifier V602.

(3) RF amplifier V602.

(a) The RF amplifier stage is used to amplify the signal and to isolate the RF oscillator from the antenna. It prevents changes in the antenna capacitance (caused by the operator's movements) from being reflected directly back into the tank circuit of the oscillator stage and causing a frequency shift. Thus, the oscillator frequency is more stable and less susceptible to outside influences.

(*b*) The signal from the RF oscillator is coupled into the grid circuit through C607. The modulating af signal is applied to the grid circuit across R606.

(c) This stage uses tube 3A4 in a class C amplifier circuit. The plate voltage, and hence the radiated signal strength, is controlled by the OUTPUT control R609. R610 is in series with R609 to limit the currrent should the stage become detuned. There are six coils in this stage, whose inductances are similar to those in the RF oscillator. These coils are not tapped, and one end of each is grounded through bypass capacitors C613 and C617. Thus only one switch section of S603 (section 1) is required by this stage. Unused coils in this stage also are shorted to prevent energy absorption. The tuning capacitor C612, is ganged to the oscillator tuning capacitor C601, so that only one tuning control is required.

(*d*) On positive alternations of the input signal from V601, grid current through V602 the low grid to cathode resistance of the tube) charges capacitor C607 negatively on the V602 grid side. On negative alternations of the signal from V601, only a small portion of the negative charge on C607 can leak off through the high resistance of V 602 grid resistors, R605 and R606. After several cycles of the signal from V601, C607 acquires an average negative charge which is effectively a negative bias between grid and cathode of V602. The output of V602 is coupled to the antenna through capacitor C611. Resistor R608 is the screen dropping resistor and C610 is the screen bypass capacitor.

(4) AF oscillator V603.

(*a*) The audio frequency oscillator employs tube 1R5 in a circuit which utilizes the negative resistance characteristic of the signal grid (grid 3) to maintain the oscillations. In a conventional oscillator it is expected that an increase in control grid potential will cause a corresponding increase in plate or anode current. In the negative resistance oscillator circuit this concept does not follow. C614 may be regarded as the key element of the circuit. In the absence of C614 a decrease in grid 2 (pin 3) voltage would result in a corresponding decrease in grid 2 current. However, with C614 in the circuit the negative going grid 2 voltage is coupled to grid 3. The coincident drop in grid 3 (pin 6) voltage feeds back toward grid 2 a great number of electrons emitted from the cathode

that would otherwise have continued to the plate. This results in a net increase in grid 2 current until the potential at grid 2 reaches the point where no further increase in the attraction of electrons is possible. At his point the magnitude of the negative-going voltage fed back from grid 2 to grid 3 starts to decrease. This is, in effect, a positive-going voltage on grid 3 the process reverses. The frequency of oscillation (approximately 800 cycles) is determined by the time constant of capacitor C614 and resistor R613. The output of the af oscillator is coupled to the grid of the RF amplifier through C609. Capacitor C608 and R607 constitute a decoupling network to prevent RF from affecting the tube's operation. R612 is the screen grid resistor.

(*b*) The audiofrequency signal thus applied to the grid of the RF amplifier stage effectively increases and decreases the grid bias on the stage at an audiofrequency rate. Varying the grid bias varies the power output, and since the power output is varying at an audio frequency rate, the RF carrier is amplitude modulated. The signal may be easily identified at the receiver by turning the MCW–CW switch S602 to the MCW position.

(5) Neon lamp relaxation oscillator E-601.

(a) The neon lamp (NE–16), in conjunction with capacitor C606 and resistor R604, forms a relaxation oscillator. Voltage across the lamp and C606 builds up slowly until the neon gas ignites (approximately 75 volts). The lamp then appears as a low resistance and discharges C606. When the voltage across the capacitor drops to approximately 60 volts the lamp is extinguished and its resistance rises to a high value thereby allowing the voltage to build up on C606 and the lamp to repeat the cycle.

(b) The flashing of the bulb, approximately every 2 seconds, indicates that the set is turned on. Each time the bulb flashes a voltage pulse is applied to the grid of the RF oscillator tube through the coupling capacitor C605. This superimposes an audible "tick" on the RF carrier, which is a further aid in identifying the target transmitter's signal at the receiver. Resistor R602 and C-616 form an RF decoupling network isolating the relaxation oscillator from the RF grid voltage on V601. The tick may be heard whether the af oscillator (V603) is on or off (switch S602 on MCW or CW).

1–8. Power Control and Protective Circuits (fig. 6–6)

Interunit power control and protective circuitry are contained in the power distribution panel, (fig. 6–6). This unit permits selecting and adjusting the line input power (115/230 vac) to the 115 vac required for operation of the system. The primary power must be 115/230 vac ±10 percent at 50 to 60 cycles supplied to either J2 or J1. respectively.

a. The front panel line input bar switch (S1, S2) permits removing all power or selecting the high or low inputs. Circuit breakers (CB1, CB2) on the front panel provide primary power overload protection.

b. Transformer T1 is a multiple tap autotransformer which makes possible the wide range of voltage adjustments required by the equipment. Voltage selection is accomplished by the use of OUTPUT VOLTAGE CONTROL switch S4, a tap selector switch. This switch is connected to the taps on T1 and provides a convenient method for selecting an output voltage. Both the output voltage level and the output voltage frequency may be continuously monitored by reading meters M1 and M2 respectively.

c. Switch S3 is provided to permit disconnecting the equipment while preliminary voltage adjustments are being made.

d. Multiple outputs (J3, J4, J5) all connected in parallel, are provided for the connection of the load.

Section IV. INTERUNIT CIRCUIT DETAILS

1–9. Operational Control Circuits

a. Two operational controls, interunit in their function are located on the front panel of the azimuth indicator of the primary console (fig. 6–17).

(1) *MON/DF control (S3) — primary console.*

(*a*) In the MON position, 6.3 vac is routed to the gonio drive chassis where it is rectified and filtered by CR3 and C4 to provide chatter-free operation of relays K1 and K2 (fig. 6–19).

(*b*) The operation of K1 and K2 removes the df signal from the balanced input of the df receiver and applies a signal from the monitor antenna to the unbalanced input of the df receiver. This permits the IF output of the receiver to be viewed on the monitor oscilloscope and the audio output to be monitored aurally without an interfering df signal.

(*c*) In addition, in the MON position, a resistor R26 is placed in series with the high voltage transformer primary to reduce the voltage to the CRT sufficiently to remove the visible trace.

(*d*) The monitor antenna is connected to the unbalanced input of the monitor receiver for all modes of operation.

(*e*) In the DF position, 6.3 vac is removed from the gonio drive chassis to deenergize relays K1 and K2. The monitor antenna is disconnected from the unbalanced input and the df signal from the rotary coupler is applied to the balanced input of the df receiver.

(*f*) The IF output of the df receiver is applied to the monitor oscilloscope and to the RF detector for processing and routing to the azimuth indicator where bearing information is displayed.

(2) *1 RCVR/2–RCVR control (S2)— primary console* (fig. 6–17).

(*a*) *1–RCVR mode.* In the 1–RCVR position, relay K1 in the RF detector is not energized. The IF output from the monitor receiver is shorted to ground and the oscillator V1 output (455 kc) is substituted instead as the input signal for the RF detector unit.

(*b*) *2–RCVR mode.* In the 2–RCVR position, relay K1 in the RF detector is energized. B+ is removed from the oscillator V1 to deactivate it. Ground is removed from the IF output of the monitor receiver and the signal is fed to the RF detector input for processing. This mode of operation is necessary where the RF detector removes all FM or PM modulation to render the signal suitable for visual presentation. Refer to paragraph 1–7*f* for the complete circuit analysis explaining how this is accomplished.

b. Two operational controls which are interunit in their function, are located on the front panel of the azimuth indicator of the secondary console (fig. 6–17).

(1) *MON/DF control (S3) — secondary console.*

(*a*) In the MON position, operation is identical to that in *a* (1) (*a*) above except that the component symbol numbers are CR4, C5, K3, and K4 (fig. 6–17).

(*b*) Operation is identical to *a* (1)(*b*) above except K3 and K4 are the components involved.

(*c*) Identical to *a* (1)(*c*).

(*d*) Identical to *a* (1)(*d*).

(*e*) Operation is the same as *a* (1)(*e*) except the relays involved are K3 and K4.

(*f*) Same as *a* (1)(*f*).

(2) *1 RCVR/2–RCVR control (S2) — secondary console.*

(*a*) Same as *a* (2)(*a*).

(*b*) Same as *a* (2)(*b*).

1–10. Voltage Distribution (System-Derived)

The following voltages are generated within units of the system and distributed to other units where required by appropriate cabling.

a. Monitor Oscilloscope Sync Voltage. The synchronizer (magnetic pick-up), driven by the secondary goniometer on the drive, goniometer rotary coupler (fig. 6–17), produces a pulse for each revolution of the goniometer at the output jack J1. A cable provides the connection from J1 to the EXT SYNC and ground terminal (fig. 6–21), on the Monitor Oscilloscope for synchronizing the horizontal sweep rate with the rational rate of the goniometer.

b. Drive Motor Voltage (180 cps). The electronic control amplifier (fig. 6–21) produces, at its output jack J2, the power needed to drive the motor on the drive, goniometer/rotary coupler (fig. 1–19). A cable connects this output from J2 to the input connector J13 on the drive, goniometer/rotary coupler chassis where a phase-shift network converts the 180 cps to a two-phase voltage to drive the split phase motor.

c. Goniometer Excitation Voltage (72 kc). A 72-kc sine wave voltage is developed in the 72 kc oscillator stage V5 of the azimuth indicater in the primary console (fig. 6–17), is processed in V2 and V3, and appears as an output at J2. A cable connects the output voltage to the primary goniometer at the 72 kc INPUT jack J5 (fig. 6–4). A duplicate 72 kc voltage is developed in the azimuth indicator in the secondary console and applied to the secondary goniometer.

d. Azimuth Indicator Sweep Voltage. The 72 kc voltages from the output jacks J1 through J4 (fig. 6–4) on the primary goniometer are connected by cables to the azimuth indicator in the primary console at J3 through J6 (fig. 6–17). Thus, two voltages displaced by 90° are fed to the horizontal and vertical deflection plates of the indicator CRT for a filled-in, circular sweep presentation. The 72-kc voltages from the output jacks of the secondary goniometer are connected similarly to the azimuth indicator in the secondary console.

1–11. Power Application

a. Line power is connected to the Direction Finder Set AN/TRD–15 at J1 (if 230 vac) or at J2 (if 115 vac) on the power distribution panel. Ganged power switch S1, S2 is thrown to the appropriate position (115Vor 230V) to apply power to the panel unit. The neutral or center location of the switch handle is the OFF position.

b. With circuit breakers CB1 and CB2 closed and the output voltage control adjusted to an indication of 115 volts, 50–60 cps on meters M1 and M2, S3 is thrown to apply controlled power to the three receptacles J3, J4 and J5.

c. Three units of the set derive their power from a line-cord connection to receptacle J3, J4 and J5. They are the monitor oscilloscope, the azimuth indicator, and the RF detector power supply.

CHAPTER 2

ORGANIZATIONAL MAINTENANCE INSTRUCTIONS

Section I. ORGANIZATIONAL TOOLS AND EQUIPMENT

2–1. General

a. The tools and materials supplied with AN/TRD–15 are listed in chapter 2, paragraph 2–5, TM 11–5825–231–10.

b. The allowable maintenance that can be performed by the using organization is dependent to a large extent upon the existing military regulations, the tactical situation, and on the other tools and test equipment issued to the using organization.

2–2. Scope

a. This chapter covers organizational maintenance of the Direction Finder Set AN/TRD–15.

b. Organizational maintenance of Direction Finder Set AN/TRD–15 consists of the following:

(1) Monthly maintenance, paragraph 2–3 *a.*
(2) Quarterly maintenance, paragraph 2–3 *c.*
(3) Lubrication, paragraph 2–4.
(4) Weatherproofing, paragraph 2–5.
(5) Rustproofing, paragraph 2–5 *d.*
(6) Troubleshooting, paragraph 2–6.
  (*a*) Visual Inspection.
  (*b*) Sectionalization of trouble to a unit.
  (*c*) Repair of defective cables.

Section II. PREVENTIVE MAINTENANCE

2–3. Preventive Maintenance

Preventive maintenance is the systematic care, inspection, and servicing of equipment to maintain it in serviceable condition, prevent breakdowns, and assure maximum operational capability. Preventive maintenance is the responsibility of all categories concerned with the equipment and includes the inspection, testing, and repair and replacement of parts, subassemblies, or units which the inspection and tests indicate would probably fail before the next scheduled periodic service. Preventive maintenance checks and services of Direction Finder Set AN/TRD–15 at the organizational level are made at monthly and quarterly intervals unless otherwise directed by the commanding officer.

a. Monthly Maintenance. Perform the maintenance functions indicated in the monthly preventive maintenance checks and services chart (*b* below) once each month. A month is defined as approximately 30 calendar days of 8-hour per day operation. If the equipment is operated 16 hours a day, the monthly preventive maintenance checks and services should be performed at 15-day intervals. Adjustment of the maintenance intervals must be made to compensate for any unusual operating conditions. Equipment maintained in a standby (ready for immediate operation) condition must have monthly preventive maintenance checks and services performed on it. Equipment in limited storage (requires service before operation) does not require monthly preventive maintenance.

b. Monthly Preventive Maintenance Checks and Services Chart.

Sequence No.	Item	Procedure	References
1	Cabinet interiors.	Open rear doors of primary and secondary consoles and check consoles and check interiors for evidence of water leakage condensation and corrosion.	
2	Electron Tubes	Check electron tubes for loose envelopes, cap connectors, cracked sockets, insufficient socket spring tension.	
3	Oil filled capacitors (CP type with metal case).	Check for leaks bulges and discoloration.	
4	Variable capacitors.	Check for dirt, moisture, misalignment of plates, and loose mountings.	Para 4–6, TM 11–5825–231–10.
5	Resistors	Check bushings and insulators for cracks, chips, blistering, discoloration, and moisture.	
6	Capacitor and resistor terminals.	Check for corrosion, dirt, and loose contacts.	Para 4–6 TM 11–5825–231–10.
7	Wafer switches	Check contacts for dirt or corrosion.	Para 4–6 TM 11–5825–231–10.
8	Terminal blocks.	Check terminal blocks for loose connections, cracks and breaks.	
9	Transformers, chokes, potentiometers, and rheostats.	Check connections, mounting hardware, and for signs of overheating or oil leakage.	
10	Cathode ray tube.	Check for burnt screen spots.	

c. Quarterly Maintenance. Quarterly preventive maintenance checks and services on Direction Finder Set AN/TRD–15 are required. Periodic weekly and monthly services constitute a part of the quarterly preventive maintenance checks and services and must be performed concurrently. All deficiencies or shortcomings will be recorded in accordance with the requirements of paragraph 4–3*c*. Perform all the checks and services listed in the quarterly preventive maintenance checks and services chart (*d* below) in the sequence listed.

d. Quarterly Preventive Maintenance Checks and Services Chart.

Sequence No.	Item	Procedure	References
1	Completeness	See that the equipment is complete.	Para 1–6*a*, TM 11–5825–231–10.
2	Installation	See that equipment is properly installed.	Para 2–6, TM 11–5825–231–10.
3	Cleanliness	See that the equipment is clean	Para 4–6, TM 11–5825–231–10.
4	Preservation	Check all surfaces for evidence of fungus. Remove rust and corrosion and spot-paint bare spots.	Paras 4–6 and 5–10, TM 11–5825–231–10.

Sequence No.	Item	Procedure	References
5	Publications	See that all publications are complete, serviceable, and current.	DA Pam 310–4
6	Modifications	Check DA Pam 310–4 to determine if new applicable MWO's have been published. All URGENT MWO's must be applied immediately. All ROUTINE MWO's must be scheduled.	
7	Gaskets	Check gaskets for moisture, oil saturation, and brittle, broken, cracked, loose, pinched, or mismatched sections.	
8	Pluckout items	Inspect clamps and seating of pluckout items. Check for wrong, bent, or broken parts.	
9	Fuses	See that all operating fuses are of the correct value. Check spare fuses for proper valve and quantity.	Para 4–*8c*, TM 11–5825–231–10.
10	Mounting	See that all bolts, nuts, and washers are correctly positioned and properly tightened. Check for cracked, bent, or broken brackets.	
11	Connections	Check to be sure that plugs and sockets are clean, intact, and not loose fitting.	Para 4–6, TM 11–5825–231–10.
12	Knobs, dials, and switches.	While making the operating checks (items 13 and 14), observe that the mechanical action of each knob, dial, and switch is smooth and free of external or internal binding.	
13	Radio receiver	Check the receiver in accordance with the preventive maintenance checks and services chart in TM 11-5820–358–20.	
14	Radio transmitter.	Check the transmitter in accordance with the quartely preventive maintenance checks and services charts in TM 11–688.	

Section III. LUBRICATION.

2–4. Lubrication

No periodic lubrication is required for Direction Finder Set AN/TRD–15. All required lubrication has been performed at the factory and is sufficient for the life of the equipment.

Section IV. WEATHERPROOFING

2–5. Weatherproofing

a. General. Signal Corps equipment, when operated under severe climatic conditions such as prevail in tropical, arctic, and desert regions requires special treatment and maintenance. Fungus growth, insects, dust, corrosion, salt spray, excessive moisture, and extreme temperatures are harmful to most materials.

b. Winter Maintenance. Special precautions necessary to prevent poor performance or total operational failure of equipment in extremely low temperatures.

c. Desert Maintenance. Special precautions necessary to prevent equipment failure in areas subject to extremely high temperatures, low humidity, and excessive sand and dust.

d. Rustproofing and Painting.

(1) When the finish on a case has been badly scarred or damaged, rust and corrosion can be prevented by touching up bared surfaces. Use No. 00 or No. 000 sandpaper to clean the surface down to the bare metal; obtain a bright smooth finish.

Caution: **Do not use steel wool. Minute particles frequently enter the case and cause harmful internal shorting or grounding of circuits.**

(2) Apply paint with a small brush, and gray enamel per Federal Specification TT–C–595, shade 26152 for all DF equipment used inside the shelter, and shade X–24087 for outside equipment.

Section V. TROUBLESHOOTING

2–6. Scope

a. The troubleshooting and repair work that can be performed at the organizational maintenance level is necessarily limited in scope by the tools, test equipment, and replaceable parts issued and by the existing tactical situation. Accordingly, troubleshooting is based on the performance of the equipment and the use of the senses in determining such troubles as burned tubes, cracked insulators, etc.

b. Paragraphs 2–7 through 2–10 help in determining which of the components, such as the goniometer or indicator, are at fault. If a unit is found to be defective, notify maintenance personnel.

2–7. Visual Inspection

Failure of this equipment to operate properly will usually be caused by one or more of the following faults:

a. Improperly connected cords or cables.

b. Worn, broken, or disconnected cords, plugs, or receptacles.

c. Burned-out fuses.

d. Defective tubes.

e. Dead batteries (transmitter only).

f. Disconnected battery plugs (transmitter only).

g. Connections broken due to rough handling or dropping of the equipment.

h. Antenna not fully extended preventing clamps from making contact with the antenna (transmitter only).

2–8. System Sectionalization of Trouble to a Component

System sectionalization consists of determining whether the trouble is in the antenna, goniometer drive, azimuth indicator, receiver, or power source. Since the output of the equipment is in terms of both visual and aural information, sectionalization is simplified. *For example:* if the antenna, rotary coupler or receiver (from the antenna input to the second i–f stage) fails there will be no aural or visual bearing, for these units are common to visual and aural signals. If the audio stage of the receiver or the speaker fails there will be no sound but the visual will be undisturbed. Similarly, trouble in the azimuth indicator stages or in the indicator goniometer does not interfere with the sound.

a. Operate the equipment and observe its performance. See daily checklist in TM 11–5825–231–10 (para 4–4, items 6 through 11) for normal operating indications.

b. If only one unit is dead, the trouble is in the component and is probably a fuse. Check fuses at an early stage in troubleshooting.

c. If a component is inoperative but the dial lights operate, check cables for loose connections.

d. Intermittent operation due to an intermittent connection may sometimes be found by tapping sharply each part and observing the visual pattern or sound.

e. Large bearing errors will result in visual operation when using a receiver selectivity other than 2 kc, or when the antenna is not set up properly, and is not perfectly symmetrical in every respect, or when the cables are damaged or crushed.

f. A single line pattern which is fixed and steady is displayed when the goniometers are not turning. Check the drive motor and the

cable and connections supplying power to the goniometer drive.

g. A single line pattern which lengthens from a dot to a line and back again in the same direction when the drive is turned manually results when one set of deflection plates in the cathode ray tube does not receive a signal. The trouble may be in the indicator deflection transformers or in the goniometer or its connections.

h. If the dial lights operate in the indicator but the cathode ray tube is dark the trouble is likely to be the high voltage supply of the indicator, poor connections to the cathode ray tube, or a defective cathode ray tube.

2–9. Troubleshooting Using Daily Equipment Preventive Maintenance Checks and Services Chart

a. General. The daily preventive maintenance checks and services chart in TM 11–5825–231–10 (para 4–4, items 6 through 11) will help maintenance personnel to locate trouble in the equipment. The list gives the item to be checked, the conditions under which the item is checked, the normal indications and tolerances of correct operation, and the corrective measures the operator can take. To use this list, follow the items in numerical sequence.

b. Action or Condition. For some items, the information given in the action or condition column consists of various switch and control settings under which the item is to be checked. For other items, it represents an action that must be taken to check the normal indication given in the normal indications column.

c. Normal Indications. The normal indications listed include the visible and audible signs that the operator should perceive when he checks the items. If the indications are not normal, the maintenance personnel should apply the recommended corrective measures.

d. Corrective Measures. The corrective measures listed are those maintenance personnel can take without turning in the equipment for repairs. If the set is completely inoperative or is the recommended corrective measures do not yield results, troubleshooting is necessary. However, if the tactical situation requires that communication be maintained and if the set is not completely inoperative, the operator must maintain the set in operation as long as it is possible to do so.

2–10. Troubleshooting Chart

Item No.	Trouble symptom	Probable trouble	Checks and corrective measures
1	System inoperative.	*a.* Circuit breaker on power panel not in.	*a.* Press circuit breaker in until a click is heard.
		b. Power cable disconnected.	*b.* Check power cable connection.
		c. Rectifier V1 defective (power supply).	*c.* Check and replace if necessary.
2	No pattern or dot on indicator.	*a.* INTENSITY control rotated fully CCW.	*a.* Check INTENSITY control for proper setting. Reset if necessary.
		b. F102, F103, F101 defective.	*b.* Check fuses. Replace if necessary.
		c. Defective cathode ray tube	*c.* See paragraph 4–2*c* for replacement procedure.
3	No pattern, dot only.	Goniometer drive inoperative.	Check POWER OUTPUT indicator on control amplifier for glow. if no glow is visible, F102 may be defective. Replace fuse if necessary.
4	No audio, pattern on indicator present.	LOCAL GAIN control on receivers rotated CCW.	Check setting of LINE GAIN; adjust as required.
5	Pattern on indicator less than full size.	SIZE control on indicator rotated CCW.	Check DF GAIN control. Rotate CW as necessary.

Item No.	Trouble symptom	Probable trouble	Checks and corrective measures
6	Bearing indication on indicator erratic.	*a.* Weak signal	*a.* Check S meter on receiver, if low, increase RF GAIN control.
		b. Defective antenna or bad antenna connection.	*b.* Check antennas. If defective antenna is noted, replace.

CHAPTER 3

TROUBLESHOOTING—DIRECT SUPPORT MAINTENANCE

Section I. GENERAL TROUBLESHOOTING TECHNIQUES

3–1. General Instructions

The depot maintenance procedures in this chapter supplement the procedures in the orgainzational maintenance instructions in chapter 2. The systematic troubleshooting procedure, which begins with the operational and sectionalization checks that can be performed at an organizational level, is carried to a higher level in this chapter. Sectionalization, localizing, and isolating techniques used in the troubleshooting procedures are more advanced. Section II provides interunit trouble shooting procedures to be performed by depot maintenance facilities; section III describes intraunit field maintenance localizing and isolating procedures.

3–2. Organization of Troubleshooting Procedures

a. General. The first step in servicing a defective direction finder set is to sectionalize the fault. Sectionalization means tracing the fault to a major functional unit. The second step is to localize the fault. Localization means tracing the fault to a defective part responsible for the abnormal condition. Some faults, such as burned-out resistors, high-leakage capacitors, arcing and shorted transformers can often be located by sight, smell, and hearing. The majority of faults, however, must be isolated by checking voltages and resistances.

b. Sectionalization. The two tests listed below are designed to reduce unnecessary work, and to aid in tracing trouble in a defective direction finder set. The Direction Finder Set AN/TRD–15 consists of the following major sections or units: antenna array, goniometer-rotary coupler drive, electronic control amplifier, radio receiver, RF detector, power supply, azimuth indicator, power distribution panel, oscilloscope, and radio transmitter. The first step is to locate the section(s) or unit(s) at fault by the following methods:

(1) *Visual inspection tests.* The purpose of visual inspection is to locate faults without testing or measuring circuits. Meter readings, scope patterns (holes or peaks) and other visual signs should be observed in an attempt to sectionalize the fault to a particular unit.

(2) *Operational tests.* Operational tests often indicate the general location of trouble. In many cases, the tests help to determine the exact nature of the fault. The equipment operational checklist (TM 11–5825–231–10, para 4–4, items 6 through 11) is a good test as a start. Additional tests are given in paragraph 3–4.

c. Localization. The tests listed below will aid in isolating the trouble. First, localize the trouble to a single stage of circuit, and then isolate the trouble within that circuit by voltage, resistance, and continuity measurements. Use the following methods of trouble localization.

(1) *Signal tracing.* Signal tracing in an orderly fashion through the units will help in isolating a trouble to a specific circuit at fault.

(2) *Voltage and resistance measurements.* Certain units of the direction finder set are transistorized and only the specified voltages and resistances should be measured. Do not make any other measurements. (An accidentical short or the application of a

voltage from the ohmmeter battery is sufficient to a burn out a transistor.) Use the voltage and resistance charts and compare them with the readings observed to locate the fault.

(3) *Troubleshooting chart.* The trouble symptoms and causes listed in the troubleshooting chart will aid in localizing trouble to a component part.

(4) *Stage gain chart.* Where applicable, certain units may be checked more readily by inserting a known voltage and observing the output voltage to determine individual stage gain. Comparison can be made with values listed in the chart.

(5) *Intermittent troubles.* Intermittent troubles, often difficult to trace, may be made to appear by methodically tapping with an insulated probe in the area of suspected trouble. Faulty tubes, components, and connections are often discovered by this method.

(6) *Signal substitution.* By introducing a signal normally processed by a unit, the repairman may check a unit rapidly, localizing the trouble to a particular stage.

3–3. Test Equipment Required

The following charts (*a* through *c* below) list test equipment required for troubleshooting the Direction Finder Set AN/TRD–15. The chart also includes specially fabricated test fixtures for simplifying testing procedures. For completing some of the test setups, the operating units of the system are sometimes used. These are listed in *b* below.

a. Test Equipment.

Item	Name	Manufacturer's No.	Type/ Model No.	Common Designation
1	AC line meter	16902	49	
2	Ammeter	03611	904	
3	Attenuator	28480	355B	
4	Attenuator, RF	04423	TG950	Attenuator
5	Audio oscillator	28480	200CD	
6	Electronic counter (alternate for item 7).	28480	524D	Counter
7	Frequency counter	28480	521E	Counter
8	Frequency counter	80740	7370	Counter
9	Frequency converter	28480	525A	Converter
10	Millivoltmeter	28480	411A	VM
11	Oscilloscope	80009	531	Scope
12	Oscilloscope (alternate for item 11).	80009	541	Scope
13	Phase meter	90101	524	
14	Radio receiver	80583	SP600VLF	Receiver
15	Signal generator	92110	2400	
16	Signal generator	28480	606A	
17	Signal generator, AM/FM	07980	202E	
18	Square wave generator	28480	211A	
19	Square wave generator (alternate for item 18).	80009	105	
20	Time mark generator	80009	180	Marker Generator
21	Transformer, variable	58474	116 or 136	Variac
22	Tube tester	03606	TV7A/U or TV7B/U.	
23	Univerter	07980	207E	
24	Vacuum tube voltmeter	28480	400D	VTVM
25	Vacuum tube voltmeter (with high voltage probe).	03606	WV77B	VTVM
26	Volt-ohmmeter	16902	260 or 269	VOM

b. AN/TRD-15 System Units.

Item	Name	Manufacturer's No.	Type/ Model No.	Common Designation
1	Drive, goniometer-rotary coupler.	92110	TG-126/TRD	Gonio drive
2	Electronic Control amplifier	92110	AM-3545/TRD	Amplifier
3	Oscilloscope	28480	120B	Scope
4	Power supply, RF detector	92110	PP-4482/TRD	Power supply
5	Radio receiver	92110	R-725/URR	Receiver

c. Test Fixtures.

Item	Name	Manufacturer's No.	Type/ Model No.	Common Designation
1	Adapter	92110	SCA53578-21B	
2	Antenna simulator	92110	SCA535759-8	Simulator
3	Coupler, insertion loss	92110	SCA536123-10B	
4	Filter low pass (P/O item 13)	80223	LM1-100	
5	Generator, 90 cps (P/O item 13)	73693	FBS258	
6	Goniometer (P/O item 13)	92110	GO-42/TRD	Gonio
7	Motor drive (P/O item 13)	92702	FBC29225-2	
8	Mounting fixture, 360° azimuth scale.	92110	SCA536123-2	
9	Termination	92110	SCA535758-21A	
10	Test circuit, B+ voltage	Signal Corps to fabricate.	See figure 3-10	
11	Test circuit filament voltage	Signal Corps to fabricate.	See figure 3-9	
12	Test fixture, amplitude modulation.	92110	SCA535757-15	
13	Test fixture, azimuth indicator. (See items 5-7 for component parts.)	Signal Corps to fabricate.	See figure 3-3	
14	Test fixture, goniometer	92110	SCA536123-10A	
15	Test fixture, insertion loss	92110	SCA535757-13	
16	Test fixture, output isolation	92110	SCA535757-12A	
17	Test fixture, phase shifter network.	Signal Corps to fabricate.	See figure 3-6	

d. Special Tools. The only special tool required is the goniometer stator spacing tool, SCA-T3908 (92110). Its common designation is spacing tool.

Section II. INTERUNIT TROUBLESHOOTING

3-4. Defective Direction Finding Operation

Faulty operation of the df set may be caused by defective or improperly connected cables or a failure in one of the functioning units of the system. Starting from the output units, tests are made in a back-to-front order to determine which unit is at fault. When the defective unit has been located, proceed to the intraunit test procedures which follow in paragraphs 3-6 through 3-14. It is assumed that the system has been operating prior to a malfunction which will be sectionalized by the following procedures. It is presumed further that the system has been tuned to a transmitting station and that df information is available for system processing.

a. Checking the Azimuth Indicator.

(1) Check that the controls of the indicator are operative.

(*a*) Rotate the INTENSITY control, noting that adequate brightness of the pattern is attainable.

(*b*) Rotate the FOCUS control, noting that a sharp, clearly defined pattern can be achieved.

(*c*) Rotate the GAIN control, observing that adequate control over the pattern length can be exercised.

(*d*) If reaction to controls is normal, proceed to (2) through (4) below.

(2) Remove cable from input jack J1 of the indicator and insert a 90 cps sine wave signal from an audio oscillator (para 3–3*a* item 5) into the jack.

(3) Note that a closed loop trace is present on the indicator whose length is dependent upon the input signal level, and whose rotation is dependent upon the deviation of the 90-cps input from the system-derived frequency. It should be possible to stop the rotation of the display briefly as the audio oscillator is tuned very slowly through the exact frequency of the system-generated 90 cps.

(4) If abnormal conditions prevail, the indicator unit is at fault and intraunit checking, as directed in paragraph 3–6 should be performed.

(5) If normal conditions are experienced in (1) through (3) above, proceed to the following interunit checks to determine the faulty unit.

(6) Remove all test equipment and reconnect all cables to complete the system.

b. Checking the RF Detector.

(1) Set the MODE switch S2 on the indicator to the RCVR–1 position and examine the df pattern on the monitor oscilloscope. The envelope of the RF pattern developed by sampling of information in sequence from the 25-antenna array should not show any missing segments (holes) or oversized segment (peaks).

(2) If the monitor pattern is normal, the RF detector is probably defective. Proceed to the intraunit checks in paragraph 3–7.

(3) If the monitor pattern is abnormal, the RF detector is probably good, but trouble exists elsewhere (cable crossovers, faulty cables or connections). Additional checking of the R detector is required ((4) below).

(4) Remove cable from RECEIVER–1, IF INPUT jack J4 of the RF detector and connect instead the output of a Boonton 207E Univerter adjusted for an output frequency of 455 kc at a level greater than 0.1 volt. Connect a Boonton 202E Signal Generator with its accessory unit, the Univerter, and an Audio Oscillator (para 3–3*a* items 17, 23, and 5) in a test configuration as shown in figure 3–1. Adjust the signal generator, 202E, to the required frequency of the univerter (150 mc) less the deviation frequency (0.5 kc). The required repetition rate of 90 times per second is achieved by adjusting the audio oscillator to 90 cps. Observe a radial open line trace on the indicator either in sync or rotating, depending upon the exactness of the 90-cps input rate with the system-derived 90 cps frequency.

(5) To check the two-receiver mode of system operation, set the MODE switch S2 on the indicator to the RCVR–2 position. All test connections remain the same as indicated in (4) above, except for the following added connection. Remove cable from the RECEIVER–2, IF INPUT jack J3 of the indicator and connect instead the output of a Hewlett-Packard No. 606A signal generator (3–3*a*, item 16 above) adjusted for an approximate 0.1-volt output at 455 kc. Observe, a radial open line in sync or rotating depending on the coorelation of the test and the system-generated 90-cps signals.

(6) If abnormal results are observed when performing the checks in either

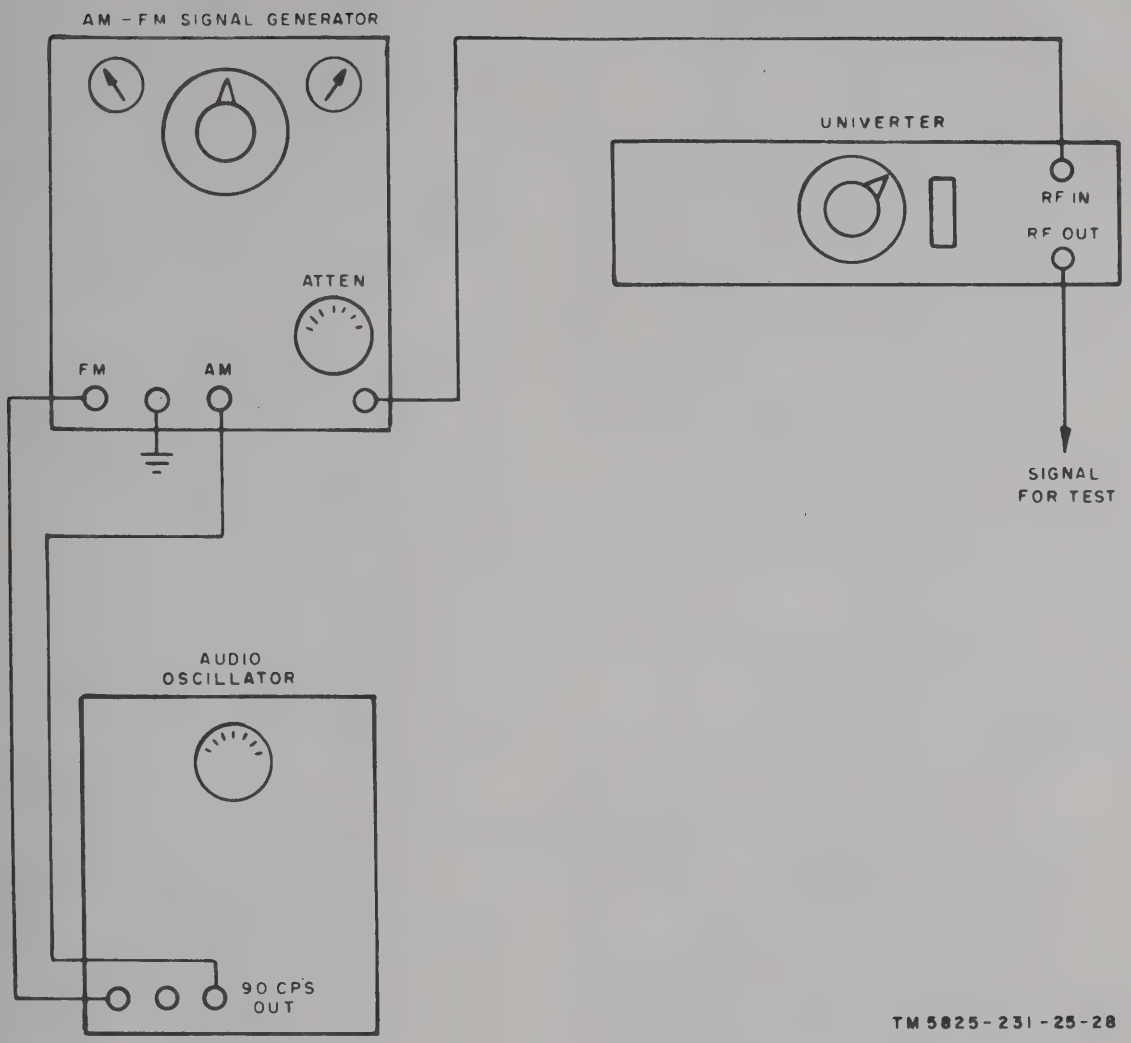

Figure 3–1. Test setup, RF detector.

(4) or (5) above, the RF detector is defective and intraunit checking must be performed according to paragraph 3–7. If normal, proceed to the interunit testing. Remove all test equipment and reconnect all cables.

c. *Checking the Primary Receiver.*

(1) Set the MODE switch S2 on the Indicator to the RCVR–1 position. Using the test equipment configuration shown in figure 3–1, connect the output of the univerter to the BALANCED ANTENNA input located at rear of the primary receiver. Set the output of the univerter to a frequency from 4.5 to 5.0 mc at 100 μv, the deviation frequency to 0.5 kc, and the repetition rate to 90 cps. Tune the receiver to the oscillator frequency, noting that the "S" meter shows a maximum deflection. A radial open-line should be displayed on the indicator, rotating or in sync depending on the agreement of the test signal with that (90 cps) generated by the system.

(2) If abnormal results are obtained ((1) above), the primary receiver is defec-

tive. Perform intraunit checks as directed in paragraph 3–9.

(3) If normal results are obtained, continue to (4) below.

(4) Set the MON–DF switch S3 on the indicator to the MON position. Remove test setup from the BALANCED ANTENNA input of the receiver, but do not reconnect the system cable. Connect instead, the test setup (fig. 3–1) to the UNBALANCED ANTENNA input of the receiver and observe an open line as in (1) above, differing only in length due to the differences in input coupling.

(5) If the results of (1) above are satisfactory, but those of (4) above are not, trouble exists at the input of the receiver. Check the input jack and associated wiring.

(6) Remove alll test equipment and reconnect all system cables.

d. Checking the Secondary Receiver.

(1) Set the MODE switch S2 on the indicator to the RCVR–2 position. Using the test equipment configuration shown in figure 3–1, connect the output of the univerter to the BALANCED ANTENNA input of the primary receiver. With the output of the univerter set to a frequency from 4.5 to 5.0 mc at 100 μv, the deviation to 0.5 kc, and the repetition rate to 90 cps, tune the receiver to the signal generator frequency.

(2) Connect the Hewlett-Packard model 606A Signal Generator (para 3–3*a*, item 16) to the UNBALANCED ANTENNA input of the secondary receiver. Adjust the generator to the same frequency to which the primary receiver is tuned and tune the secondary receiver to this frequency, noting a maximum deflection on the "S" meter. Observe a radial open line either in sync or rotating, depending on the similarity of the test and system-generated 90-cps signals.

(3) If the results obtained in (2) above are abnormal, perform the intraunit checks as directed in paragraph 3–9 for the secondary receiver.

(4) If the results in (2) above are normal, remove all test equipment and reconnect all system cables.

e. Drive, Goniometer-Rotary Coupler.

(1) Connect antenna simulator SCA535-759–8 (para 3–3*c*, item 2) to the antenna panel of the console by removing cables from the antenna array and appropriately connecting those of the simulator. The output of the simulator, when properly processed by the rotary coupler, receiver, and RF detector will appear on the monitor oscilloscope as continuously sampled RF amplitudes and, when processed by the receivers, RF detector and azimuth indicator, will be displayed on the indicator as a propeller-shaped trace pointed in the direction of the simulated transmission.

(2) If the displays on the monitor oscilloscope and the azimuth indicator are improper, the rotary coupler or its associated cabling may be at fault. Visually check condition of mechanical couplings, cables and cable connections. Replace defective unit. If rotary coupler requires replacement, follow the alignment procedures in paragraph 3–10.

(3) If the displays required by (1) above are proper, the trouble is probably originating in the antenna installation. Defective cables, improper grounding, faulty antennas (particularly antenna coupling) and a poorly chosen antenna site may be contributing factors.

(4) If the df display on the second console drifts with respect to the first, check the belt driving the secondary goniometer. Replace worn or slipping belt. A drifting monitor oscilloscope pattern is also indicative of a slipping belt driving the secondary goniometer.

(5) If the df displays on both consoles are proper, but the monitor oscilloscope cannot be synchronized (pattern drifitng — not locked in) the sync generator and its associated circuitry is not providing an appropriate pulse (one pulse for each revolution of the goniometer) for synchronizing the horizontal sweep for the monitor oscilloscope.

(6) If the MODE switch S2 on the azimuth indicator cannot select either RCVR–1 or RCVR–2 operation, remove the cable from J10 on the indicator. With a VOM (para 3–3*a* item 26), check for zero ohms across J10 (A and B) in the RCVR–1 position and infinite ohms in the RCVR–2 position. If normal, the trouble is probably in the relay section of the gonio drive chassis. Perform the intra unit checks in paragraph 3–10. Reconnect cable.

(7) If the MON–DF switch S3 on the azimuth indicator cannot select either MON or DF mode of operation, remove the cable from J11 on the Indicator. With a VOM (para 3–3*a* item 26), check for 6.3 VAC across J11 (A and B) when in the MON position and zero VAC in the DF position. If normal, the trouble is probably in the relay section of the gonio drive chassis. Perform the intraunit checks in paragraph 3–10. Reconnect cable.

f. Amplifier, Electronic Control.

(1) If the conditions in *a* (3) above were met, where the rotation of the open line could be stopped, the electronic control amplifier is providing sufficient power at the controlled frequency of 180 cps to drive the motor at its synchronous speed.

(2) If motor speed is varying, the amplifier is at fault. Perform intraunit checking as directed in paragraph 3–11.

Section III. UNIT TROULESHOOTING PROCEDURES

Caution: **Do not attempt removal or replacement of parts before reading the instructions in paragraph 4–2.**

3–5. General

Once a malfunction has been sectionalized to a particular unit by following the procedures in section II, the service technician is concerned solely with localization and isolation of the defective part. The procedures which follow, therefore, are presented in logical fashion in their entirety for each unit. Reference to many individual sections of this manual for a complete and comprehensive test of a particular unit is thus avoided and the technician may proceed in an orderly manner until the malfunctioning component is isolated. The units of the system are presented in the same back-to-front order as they were treated in section II.

3–6. Azimuth Indicator

a. Checking B+ and Filament Circuits for Shorts.

(1) *When to check.* When any of the following conditions apply, check for shorted circuits and remove the trouble before applying power to the unit.

(*a*) When sectionalizing testing indicates power supply troubles.

(*b*) When operational reports indicate possible power supply problems.

(*c*) When unit is received for bench check with unknown symptoms.

(2) *Conditions for tests.* Perform the following steps in preparing for the short circuit tests:

(*a*) Disconnect cable connections to J1, J2, J3, J9, J10, and J11.

(*b*) Remove the azimuth indicator unit from the console.

(*c*) Invert unit on bench preparatory to performing the tests in the chart in (*d*) below.

(*d*) A VOM (para 3–3*a* item 26) is necessary for performing the resistance measurements required by the following test.

Short Circuit Tests—Azimuth Indicator

Test points	Resistance	Isolating procedure
Junction CR9 and C34 to Ground (High voltage power supply).	3 Megohms	A low resistance indicates— (1) *Breakdown of wiring insulation.* Check all high voltage wiring and components for possible short or arcover to ground (shassis). (2) *Component Failure.* Check capacitors for leakage resistance and diodes for proper front-to-back resistance ratios. Remove tube socket from CRT to check for possible interelement tube short. Check transformer for high voltage and filament winding to ground leakage.
Junction R87 and C29 to Ground (Low voltage power supply).	12,000 ohms	A low resistance indicates— (1) *Breakdown of wiring insulation.* Check the low voltage B+ wiring for any evidence of shorting to ground. (2) *Component Failure.* Check capacitors for leakage resistance (C29, C4) and dropping resistors for overheating.
Junction R61 and C31 (Unregulated B+ line) to Ground.	Infinite	A low resistance indicates— (1) *Breakdown of wiring insulation.* Check the unregulated B+ wiring for any evidence of shorting to ground. (2) *Component Failure* Check capacitor C31 for leakage resistance. Check 5-volt filament winding of transformer for leakage resistance to ground. *Note.* Determining the existence of a possible short in the 6.3-volt filament wiring is difficult because of the low dc resistance of the transformer winding. Use visual check only at this point.

b. Bench Test Setup.

(1) Bench testing of the azimuth indicator is required when interunit tests indicate that failure of system operation is due to a malfunction within the unit.

(2) Test equipment required.

Instrument	Mfr. code No.	Type or model No.
AC line meter	16902	49
Audio oscillator	28480	200CD
Electronic control amplifier.	92110	AM–3545/TRD

Instrument	Mfr. code No.	Type or model No.
Frequency counter	28480	521E
Oscilloscope	80009	531
Test fixture	Signal Corps to fabricate.	See figure 3–3
Vacuum tube voltemeter (with high voltage probe).	03606	WV77B
Variable transformer	58474	116

(3) Connect the test equipment tabulated in the chart above in a test configuration as shown in figure 3–2.

(4) Test fixture, illustrated in figure 3–3 should be fabricated as a test unit to be used whenever intraunit testing is required of the azimuth indicator. Properly label as Test Fixture AN/TRD–15, Azimuth Indicator Unit Test.

(5) Bench test operation. Perform the following operations to simulate system operation of the azimuth indicator in a bench test setup. When proper response to any of the steps below is not achieved, reference is made to the associated item in the troubleshooting chart.

(*a*) Turn indicator power switch S1 to the ON position.

(*b*) Adjust INTENSITY control fully CCW.

(*c*) Rotate DIMMER control for sufficient alidade illumination (see item 1 (*d* below) of troubleshooting chart if no response).

(*d*) Adjust DF GAIN and SIZE controls fully CCW.

(*e*) Adjust INTENSITY control to obtain a spot (see Item 2 of troubleshooting chart if no display).

(*f*) Adjust FOCUS control for sharpest definition (see Item 3 of troubleshooting chart if unable to focus).

(*g*) Adjust H and V centering controls to position spot under the alidade centering dot (see Item 4 of troubleshooting chart if spot cannot be centered).

(*h*) Apply power to test fixture (fig. 3–3).

(*i*) Adjust SIZE and SHAPE controls to produce a full scale circular pattern (see Item 5 of troubleshooting chart if pattern size is too small).

(*j*) Readjust INTENSITY and FOCUS controls as necessary.

(*k*) Turn on and adjust audio oscillator for 3 volts peak-to-peak at 90 cps (see Item 6 of troubleshooting chart if pattern is circular only).

(*l*) Readjust audio oscillator around 90 cps to minimize rotation of display which should simulate the half-propeller presentation of df information except for finite direction (see item 7 of troubleshooting chart if any secondary bearing display, ghosts or smears are evident)

c. Localizing Troubles.

(1) *General.* Procedures are outlined in the following chart for localizing troubles to a particular section or stage within the azimuth indicator. With the use of normal troubleshooting techniques and the voltage resistance charts which follow, the trouble can be isolated to a particular part.

(2) *Use of chart.* The troubleshooting chart is designed to supplement operational checks performed as directed in chapter 2 and the interunit sectionalization checks described in paragraph 3–4. If previous operational or sectionalization checks have resulted in reference to a particular item of the troubleshooting chart, go direct to the referenced item. If no previous sysptoms are known, begin with item 1 of the equipment performance checklist in paragraph 2–10

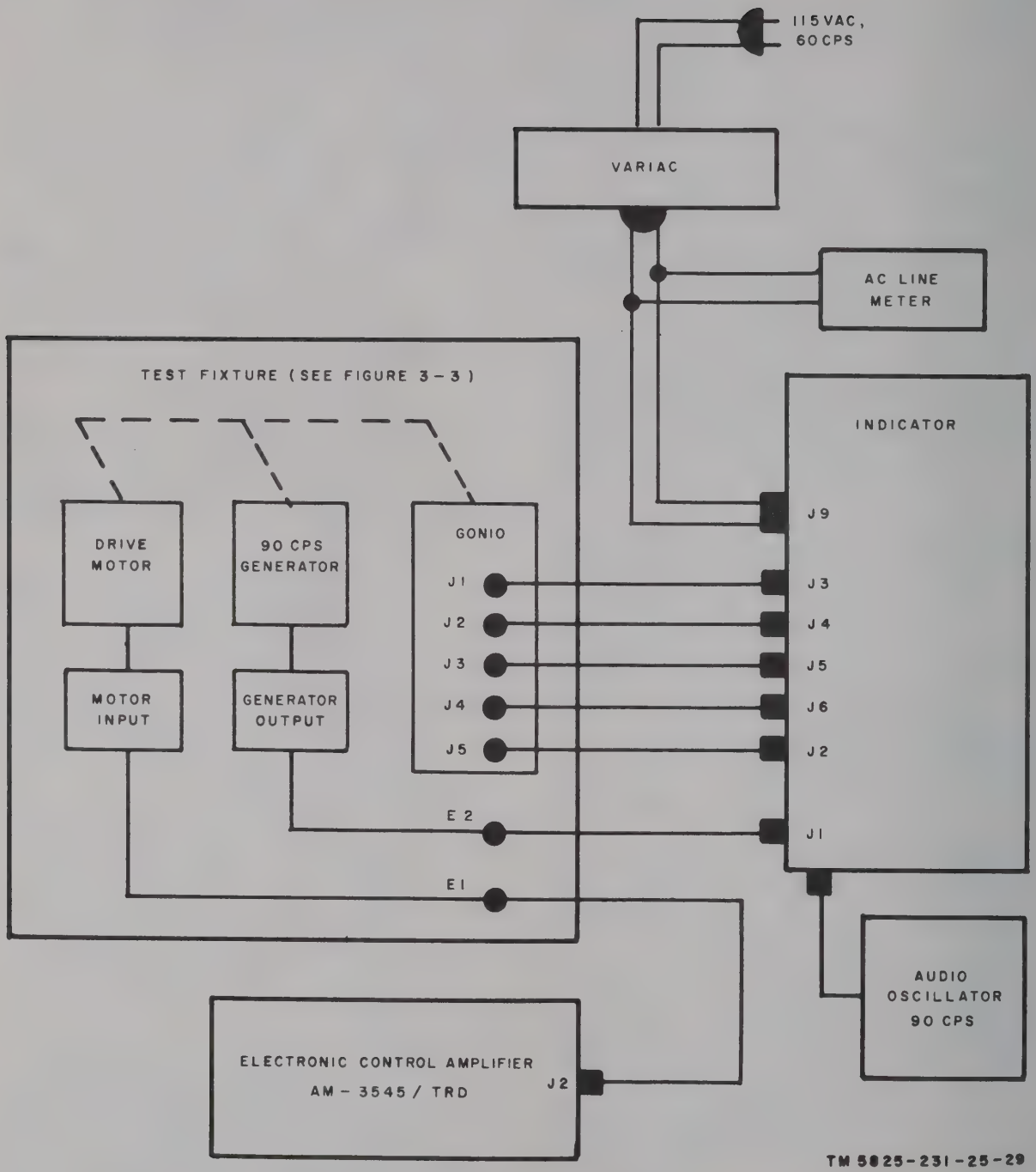

Figure 3-2. Test setup, azimuth indicator.

and proceed until the trouble is located.

Caution: **If operational symptoms are not known, or the possibility of a short circuit exists within the indicator, perform the short circuit checks described in *a* above before applying power to the unit.**

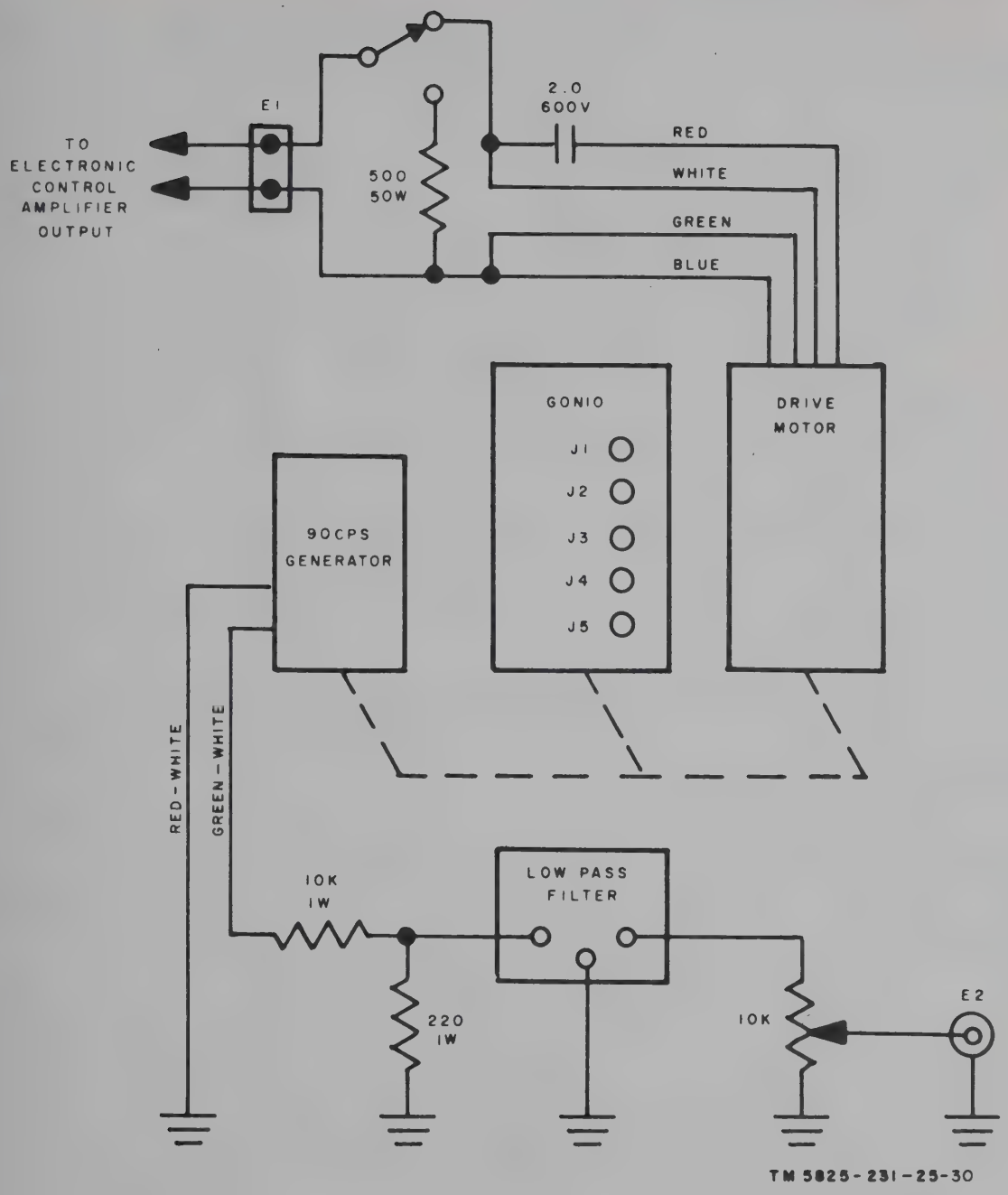

Figure 3–3. Test fixture, azimuth indicator.

(3) *Conditions for tests.* All checks outlined in the troubleshooting chart are to be conducted with the azimuth indicator connected in a test configuration as described in *b* above, and illustrated in figures 3–2 and 3–3. Refer to photographic views of the indicator to locate the stages and components listed (fig. 3–4).

d. Troubleshooting Chart—Azimuth Indicator.

Item	Trouble	Probable cause	Remedy
1	No alidade illumination (para 3–6*b*. (5) (*c*)).	Fuse open	Check F1, F2. Replace.
		Lamps open	Check DS1–DS4. Replace.
		Control open	Check R74. Replace.
2	No indicator display (para 3–6*b* (5) (*e*)).	Defective tube	Check voltages at tube socket XV4. If satisfactory, replace CRT V4.
		Low or no high voltage	Check for –4000DC at XV4, pin 2 to ground.
		Defective rectifier	Check CR8, CR9. Replace.
		Defective filter	Check C34, C35. Replace.
		Defective control	Check R60. Replace
		Low voltage supply defective	Check for +275 VDC at XV9, pin 6 to ground. See item 8 in this chart.
3	Poor focus (para 3–6*b* (5) (*f*)).	Defective control	Check R57. Replace.
		Defective divider	Check R50–R60, R83–R85. Replace.
4	Connot center pattern (para 3–6*b* (5) (*g*)).	Defective controls	Check R48, R49. Replace.
		Defective divider	Check R51, R52. Replace.
5	Insufficient pattern size, or dot pattern only in center of screen (para 3–6*b* (5) (*i*).	Defective tube	Check tubes V1, V2, V3, V5, V6. Replace.
		Defective control modulator stage	Check socket XV2 voltages/resistances.
			Check component. Replace.
		Defective amplifier stage	Check socket XV3 voltages/resistances.
			Check component. Replace.
		Misalignment	Check alignment procedure (para 4–4).
		Defective size (vertical) channel	Check transformer T5 and associated compoments from 72-kc input at J5 and J6 to CRT deflection plates. Replace defective component.
		Defective shape (horizontal) channel.	Check transformers T4 and associated components from 72-kc input at J3 and J4 to CRT deflection plates. Replace defective component.
		72-kc oscillator, cathode follower stages defective.	Check XV5, XV6A voltages/resistances.
			Check components of V5, V6A stages. Replace defective part.
6	Circular pattern only (para 3–6*b* (5) (*k*)).	Defective data amplifier	Check XV1 voltages/resistances.
			Check components of V1 stage. Replace defective component.
7	Dual bearing pattern (para 3–6*b* (5) (*l*)).	Defective blanking circuitry	Check tubes V6, V7.
			Check voltages/resistances XV6B, XV7.
			Check components of V6B, V7 stages from V1, pin 8 to V4, pin 3. Replace defective part.

Item	Trouble	Probable cause	Remedy
8	Low voltage power supply:		
	Low or no output	Defective tube	Check tubes V8, V9, V10, V11. Replace defective tube.
	Oscillation	Unbalanced regulator tube	Replace V9 (6AS7G).
		Defective resistor	Check R63, R64, R65, R66. Replace.
	Poor or no regulation	Weak regulator tube	Replace V9 (6AS7G).
		Weak amplifier tube	Replace V10 (5693).
		Weak voltage reference tube	Replace V11 (OB2WA).
		Input voltage to regulator low	Check voltage across C31 for min 400 VDC.
		Weak retifier	Replace V8 (5R4WGY).
		Defective series resistor	Replace R61.
		Defective filter	Replace C31.
	High ripple	Defective filters	Check C31, C29. Replace.
		Defective hum balance circuit	Check R67, C32. Replace.
	Cannot adjust to +275VDC.	Defective control, divider	Check R71, R72 and R73. Replace.

e. Isolating Troubles. When trouble has been localized to a stage through preceding operational and intraunit checks, use the following techniques to isolate the defective part.

(1) Test the tube involved, either in a tube tester (para 3–3*a*, item 22) or by substituting a similar type tube which is known to be functioning normally.

(2) Take voltage measurements at the tube socket using the voltage resistance chart (fig. 6–14).

(3) Abnormal ac voltages are indicative of loss of signal or loss of stage gain. Open, lossy or shorted capacitors are the most likely sources of trouble.

(4) Abnormal dc voltages are usually indicative of resistive changes in the stage. Take resistance measurements, using the voltage/resistance chart, (fig. 6–14).

(5) If the directions in (1) through (4) above do not uncover a defective part, turn to paragraph 4–4 for alignment instructions.

(6) Use schematic diagram for tracing signal flow and intercircuit measurements (fig. 6–17) and photographic presentation for physical location of parts (fig. 3–4).

f. Additional Troubleshooting Data. The tests in (1) and (2) below are proposed so that certain troubles with specific or unusual symptoms may be corrected without going through a tedious series of testing to finally isolate the cause of the malfunction.

(1) *Loss of 72 kc,* as evidenced by only a spot display on the Indicator, may be caused by an open primary winding of transformer T3. Observe the screen grid of V3. If it is glowing brightly, plate voltage is absent. Replace open transformer and tube which may have been damaged by the absence of plate potential and excessive screen current.

(2) *No indicator display* may be due to the loss of voltage from the low voltage supply. Observe rectifier tube V8 which can show a cherry-red glow of the plates if a short is present or a blue glow if the tube is gassy. Remove short, if present, and for either condition replace tube. Observe regulator tube V9 which can display a red glow of the plate if an overload is present. Remove overload condition and replace tube. A defective reference tube V11 (or in the absence of sufficient striking voltage) will show no internal glow. Replace tube or correct cause of abnormal striking voltage which may be due to a defective

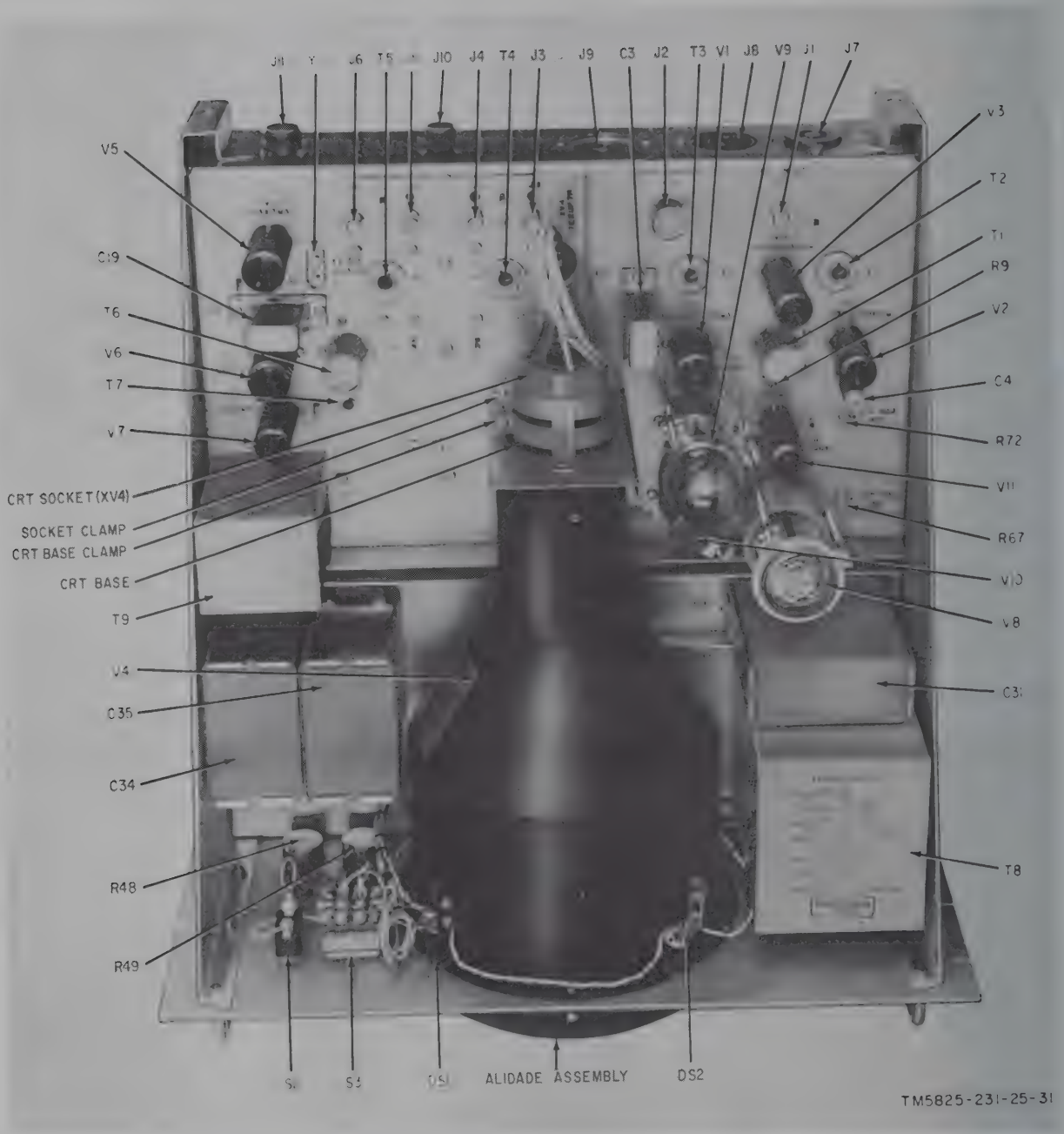

Figure 3–4 (1). Azimuth indicator, top view, location of parts.

dc amplifier tube V10. Excessive current through V11 will cause tube to glow brightly and expire quickly.

3–7. RF Detector

a. Checking B+ and Filament Cicuits for Shorts.

(1) *When to check.* When any of the following conditions apply, check for shorted circuits and remove the trouble before applying power to the unit.

(*a*) When sectionalizing testing points toward power supply troubles.

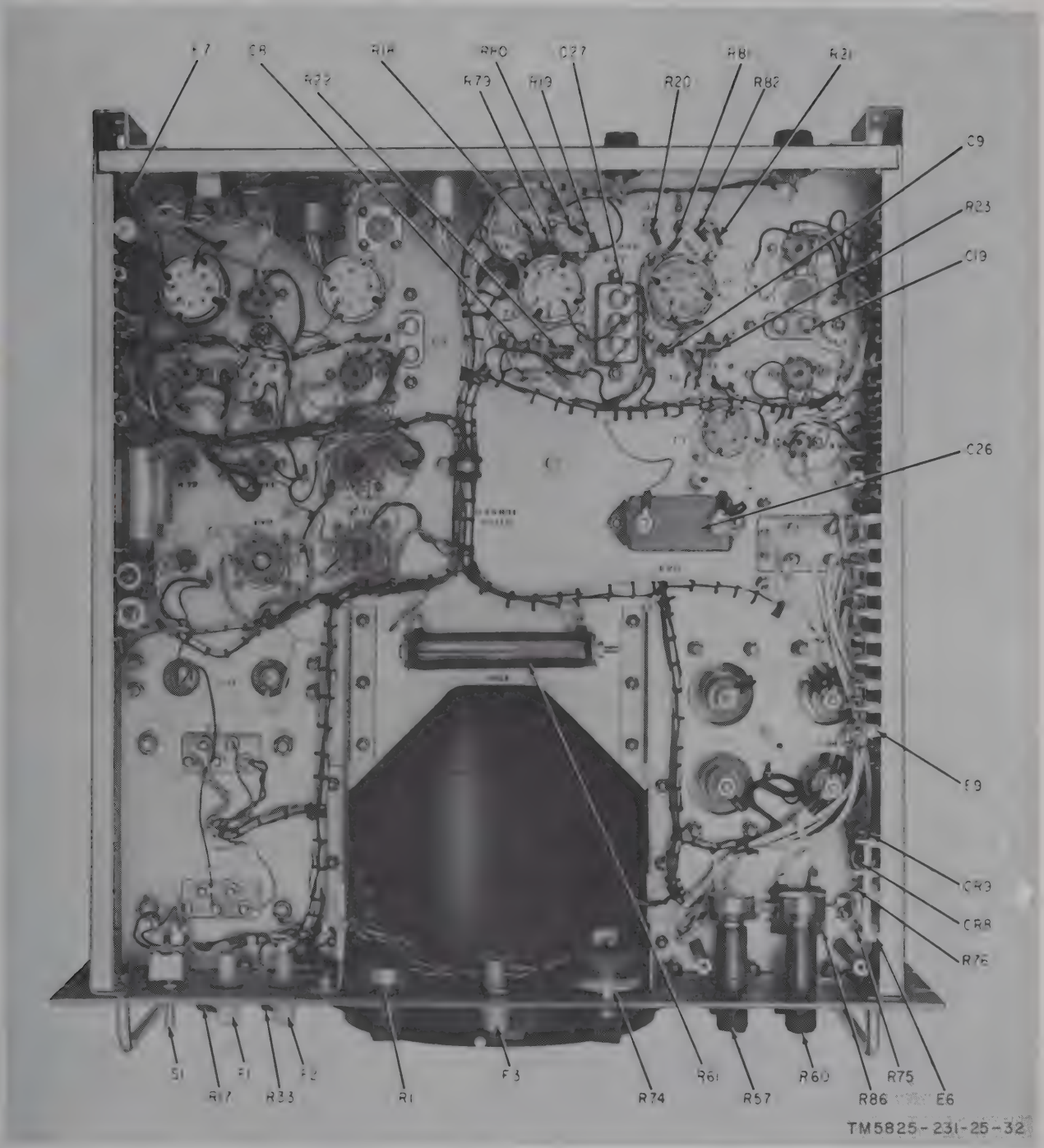

Figure 3–4 (2). Azimuth indicator, bottom view, location of parts.

(*b*) When operational reports indicate possible power supply problems.

(*c*) When unit is received for bench check with unknown symptoms.

(2) *Conditions for Tests.* Perform the following steps in preparing for the short circuit tests.

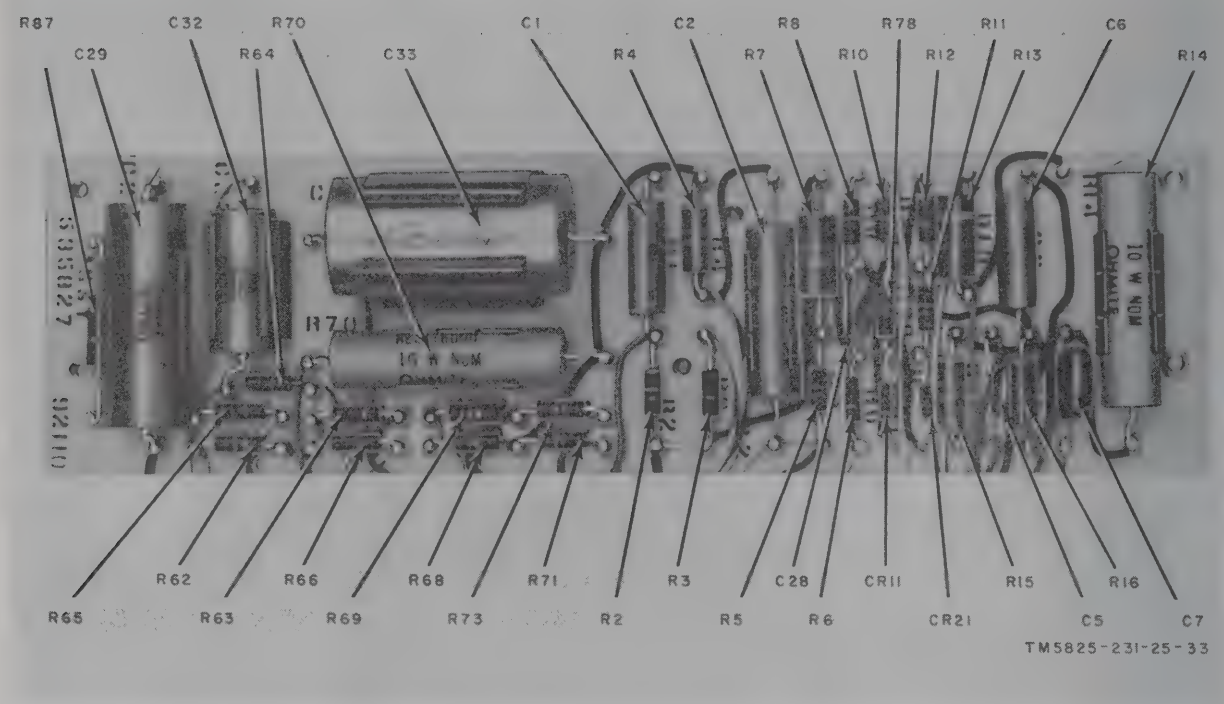

Figure 3–4. (3). Azimuth indicator, component board E7.

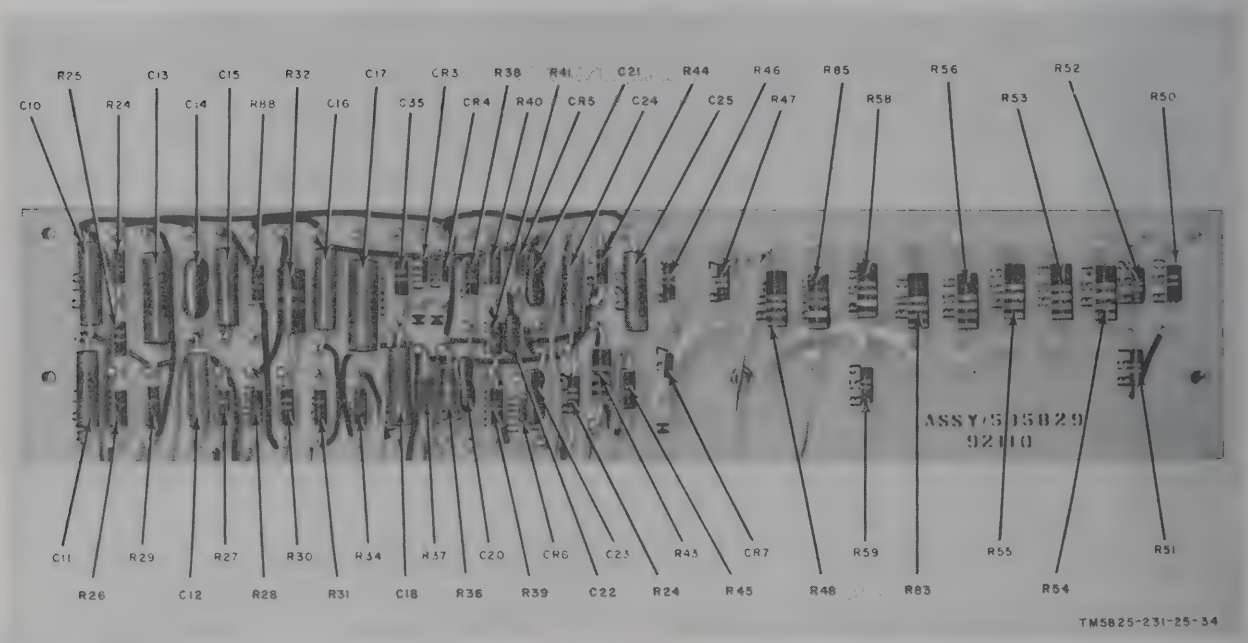

Figure 3–4 (4). Azimuth indicator component board E9.

(*a*) Disconnect cable connections to J1 through J8.

(*b*) Remove the RF Detector unit from the console.

(*c*) Set unit on bench preparatory to performing the tests in the chart in (*d*) below.

(*d*) A VOM (para 3–3*a*, item 26) is necessary for performing the resistance measurements required by the following test:

Short Circuit Tests—RF Detector

Test points	Resistance	Isolating procedure
TP13 to ground	240 K	A low resistance indicates— (1) *Breakdown of wiring insulation.* Check all B+ wiring and lead dress of components for possible short or arcover to ground (chassis) (2) *Component failure.* Remove all tubes one at a time observing any significant change in B+ resistance to ground. Return tubes to appropriate socket immediately after it has been determined that the tube is not contributing to the low resistance. Check capacitors for leakage resistance especially C4, 11, 16, 22, 26, 31, 36, 41, 47, 51, 55, 61, 63, 65, 71, 76, 78, 80, 81, and 90.
J8–A to ground	∞	Remove all tubes, identifying each with the location from which they were taken. Measure infinite resistance across the test points as a check against filament wiring shorts.
J8–B to ground	∞	Do.
J8–A to J8–B	∞	Same as above. Replace tubes in sockets from which they were removed.

b. Bench Test Setup.

(1) Bench testing of the RF detector is required when interunit tests indicate that failure of system operations is due to a malfunction within the unit.

(2) Test equipment required.

Instrument	Mfr. code No.	Type or model No.
AC line meter	16902	49
VTVM	28480	400D
Audio oscillator	28480	200CD
Electronic counter	28480	524D
Oscilloscope	80009	541
Phase shifter network (test fixture).	92110	SCA535755–19
Signal generator	28480	606A
Signal generator AM/FM	07980	202E
Univerter	07980	207E
Variac	58474	116
VOM	16902	269/260

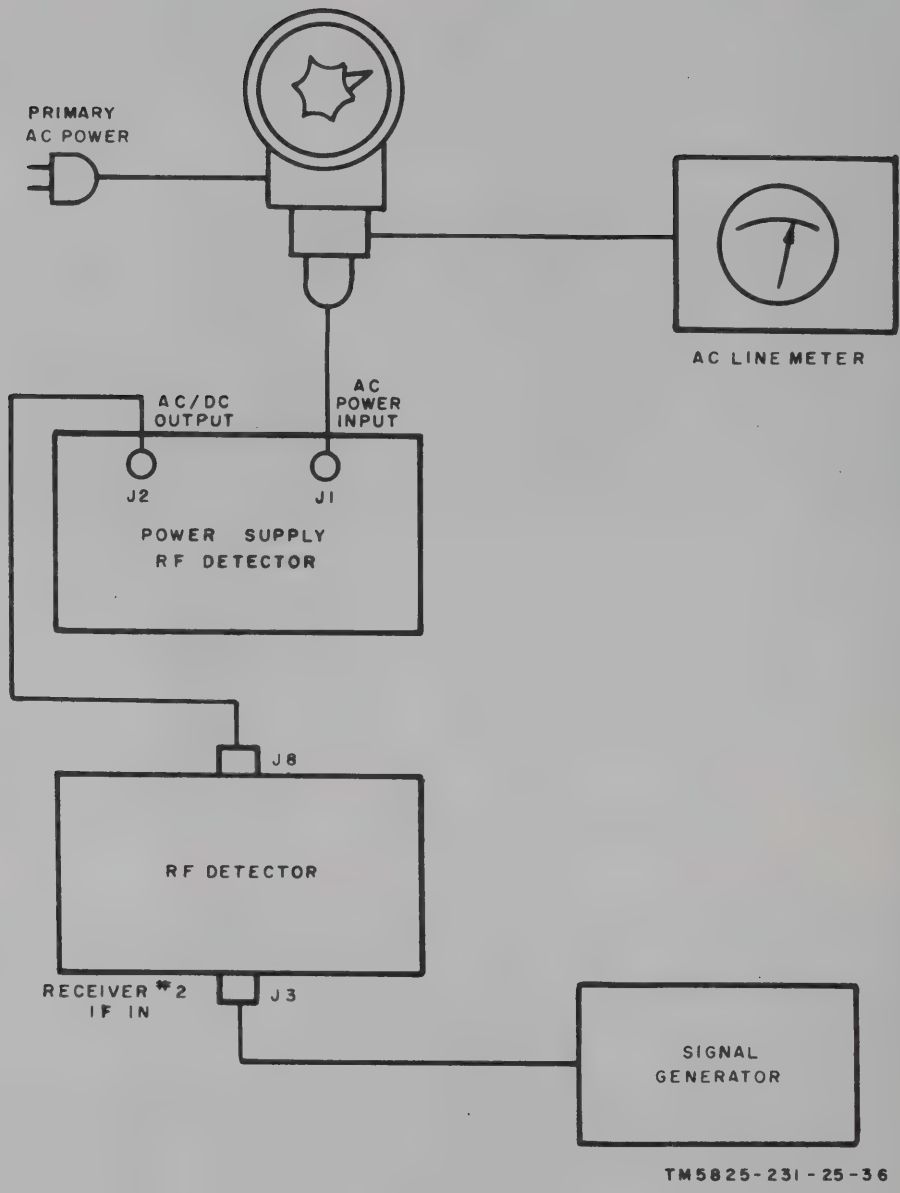

Figure 3–5. Bench test setup, RF detector.

(3) Connect the test equipment tabulated in the chart above in a test configuration as shown in figure 3–5.

(4) Fabricate a phase shift network test unit as shown in figure 3–6 to complete the test setup.

(5) Bench test operation. Perform the following operations to simulate system operation of the RF detector in a bench test setup. When proper response to any of the steps below is not achieved, refer to the associated item in the troubleshooting chart.

(*a*) By means of a jumper cable connect the audio oscillator to J2 (audio input) on the rear of the RF detector.

(*b*) Adjust the audio oscillator to a 1.0-volt rms level at 1000 cps. Use

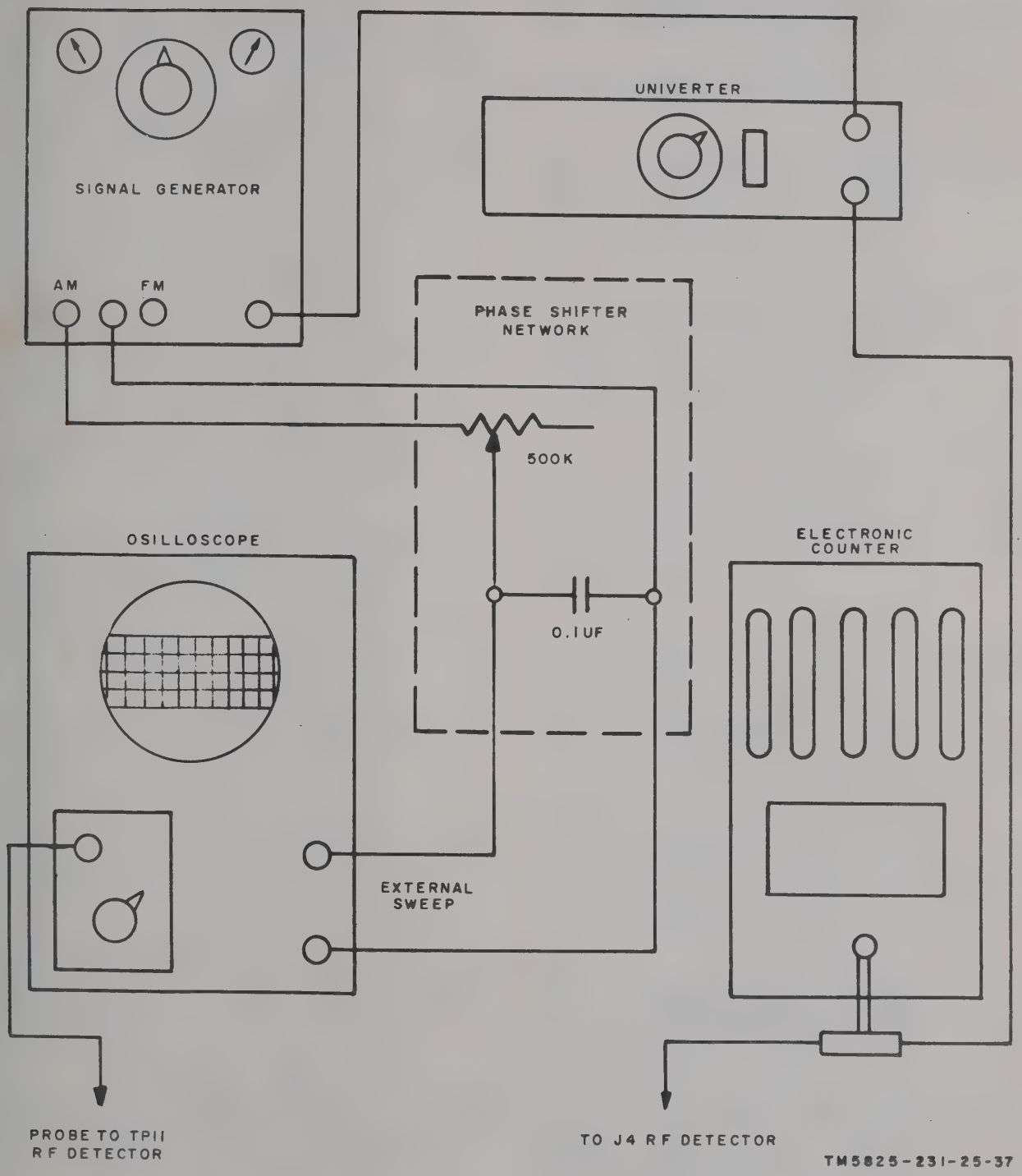

Figure 3–6. Phase shift network, test fixture.

the 400D VTVM to verify this level.

(*c*) Note a moderately loud, clear 100-cycle tone emanating from the loudspeaker. If not, refer to item 1 of the troubleshooting chart.

(*d*) Set aside the cables and test equipment after disconnecting them from the RF detector.

(*e*) Apply primary power adjusted to 115 volts rms as read on the AC line meter.

(*f*) Connect the VOM (set to 8 VAC scale) to pins 3 and 4 filament, connections of V1. The voltage measured should be 5.9 to 6.5 VAC.

(*g*) Remove VOM and with scale setting at +400 VDC insert positive probe into TP13 and the negative to ground. Voltage measured should be 245 to 255 VDC.

(*h*) Remove VOM.

(*i*) Insert the scope (531) probe into TP1 observing a peak-to-peak amplitude of the 455 kc signal between the limits of 0.2 and 2.0 volts. If not, refer to the troubleshooting chart, item 2.

(*j*) Use a test lead to short out the two contacts of J1 noting that the 455 kc signal disappears. Leave jumper connected during the following checks. Remove scope connection from TP1.

(*k*) Connect the signal generator (606-A) to the RECEIVER 1, IF INPUT, J4 on the RF Detector and adjust the input signal level to 100 mv at 455 kc, modulated 30 percent with 1000 cps.

(*l*) Insert the scope probe into TP7 and examine the pattern after crystal Y3 has been removed. Amplitude variations (vertical amplitude) produced by the 1000 cps modulation should not exceed 2 percent and frequency variations (horizontal shifting) due to nonsymmetrical limiting should not be greater than 10 percent of one complete cycle. If so, work forward with the scope probe, examining the output of each limiter stage until the nonsymmetry is located. Refer to item 3 of troubleshooting chart for additional information.

(*m*) Insert the scope probe into TP7 and observe the peak-to-peak voltage when modulation from the signal generator is removed and the rf level increased to 500 mv. The peak-to-peak level at TP7 should be between 15 and 20 volts. Reduce the signal generator level to 2 mv, observing that the peak-to-peak voltage at TP7 remains between 15 and 20 volts. The difference between the two output voltages for the change in input level should be less than 0.2 volt. If not, refer to item 4 of the troubleshooting chart.

(*n*) Remove the signal generator from J4, the oscilloscope from TP7, and replace crystal Y3.

(*o*) Connect the signal generator output to the RECEIVER 2, IF INPUT at J3 on the RF Detector, and adjust for a signal level of 100 mv at 455 kc modulated 30 percent with 1000 cps.

(*p*) Insert the scope probe in TP3 and examine the pattern after crystal Y2 has been removed. The amplitude and frequency variations should be no greater than the requirements in step (*l*) above. Complete the instructions in steps (*l*) and (*m*) for this chain of limiting stages.

(*q*) Remove the signal generator from J3, the oscilloscope from TP3, and replace crystal Y2. Remove the jumper installed in (*j*) above from the contacts of J1.

(*r*) Connect the output of the signal generator (606A) to the RECEIVER 1, IF INPUT at J4 and adjust the input level to 200 mv at 455 kc with no modulation.

(*s*) Insert the scope probe into TP9 and measure the peak-to-peak amplitude of the kc signal present at this point. The voltage level should be between 4.0 and 5.0

volts. If not, refer to item 6 of the troubleshooting chart.

(*t*) Remove the signal generator from J4 and the oscilloscope from TP-9.

(*u*) Assemble and connect the test arrangement shown in figure 3–6.

(*v*) Adjust the signal generator (202-E) to an output level of 200,000 microvolts, and the frequency to 455 kc +0.5 kc. Set the selector switch to the FM position, the internal modulation frequency control to 100 cps, and the deviation control for an indication of 1 kc on the deviation meter.

(*w*) Insert the test probe of the oscilloscope (set to internal sweep) into TP11 (df output test point). A peak-to-peak reading of exactly 5.0 volts should be obtained with a 115 volt line. If not exactly 5.0 volts, adjust D.F. LEVEL control R89 to obtain the exact voltage. If voltage is not close to 5.0 volts and cannot be brought in by an adjustment of R89, check back through the amplifier stages and filters for a loss in gain. See item 7 of the troubleshooting chart for further instructions.

(*x*) By means of the variac, first increase the line voltage to 125 volts and then decrease it to 105 volts, noting that the peak-to-peak voltage reading obtained in step (w) does not vary by more than +0.2 volt. If more than +0.2 volt refer to item 8 in the troubleshooting chart.

(*y*) Restore the line voltage to 115 volts and set the oscilloscope to EXTERNAL X1. Increase the deviation on the signal generator (202E) until the deviation meter indicates 3 kc. Using the oscilloscope controls, duplicate as closely as possible the pattern shown in figure 3–7. The phase adjusting network of the test setup must be set to produce as nearly a single line as possible. Incorrect patterns are shown in figure 3–7. Refer to items 9 and 10 of troubleshooting chart (*d* below) for further instructions if correct pattern cannot be obtained.

(*z*) Remove the oscilloscope probe from TP11 and restore oscilloscope to INTERNAL SYNC for normal operation.

(*aa*) Insert the test probe of the oscilloscope into TP12, AUX. OUTPUT, and record the peak-to-peak voltage present with exactly 3 kc deviation at 100 cps.The voltage should be between 10 and 18 volts. Reduce the deviation on the signal generator 202E) to 1 kc, noting that the voltage at TP12 will drop to within 3 to 5 volts. If the voltages required are not observed, refer to item 11 in the troubleshooting chart.

(*ab*) Remove the test equipment. Restore test setup shown in figure 3–5 and connect VTVM. Connect audio oscillator to the arm of R89 and ground (chassis). Set the audio oscillator for 90 cycles at a level to produce a +10 dbm on the VTVM.

(*ac*) Tune the oscillator to 180 cps, centering it in the output null. The null must not be less than 30 dbm deep, a reading of –20 dbm on the meter.

(*ad*) Tune the oscillator to 270 cps and adjust for null. The depth of the null again must be at least 30 dbm.

(*ae*) Tune the oscillator to 360 cps, adjust for a null, and observe the depth of the null to be at least 30 dbm.

(*af*) If the condition in (*ac*), (*ad*), and (*ae*) cannot be met, refer to item 12 of the troubleshooting chart.

(*ag*) Remove test equipment, shut off main power, and remove connecting cables.

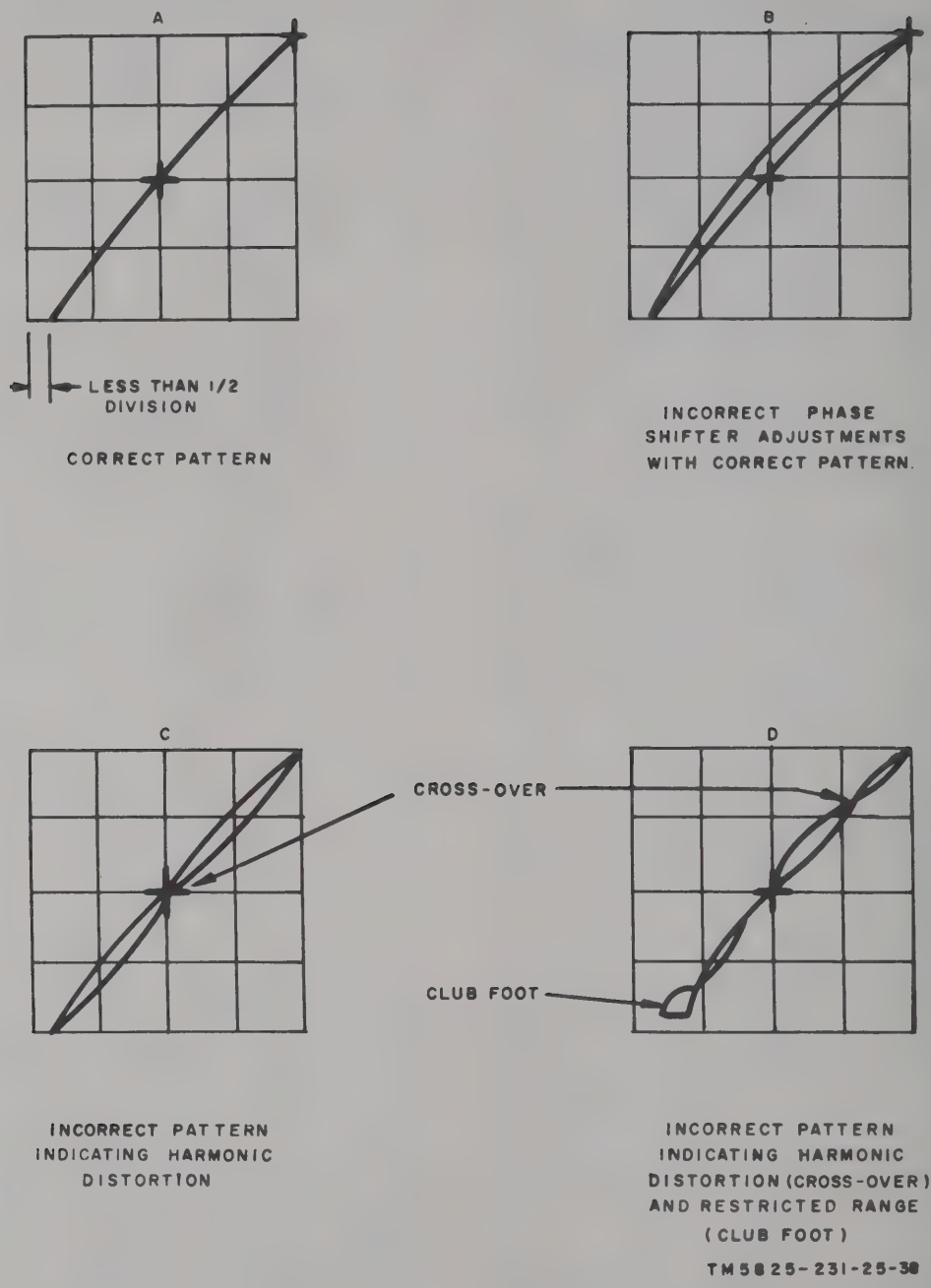

Figure 3–7. Test patterns.

c. Localizing Troubles.

(1) *General.* Procedures are outlined in the following chart for localizing troubles to a particular section or stage within the RF detector. With the use of normal troubleshooting techniques and the voltage resistance charts which follow, the trouble can be isolated to a particular part.

(2) *Use of chart.* The troubleshooting chart is designed to supplement operational checks performed as directed in chapter 2 and the interunit sectionalization checks described in paragraph 3–4. If previous operational or sectionalization checks have resulted in reference to a particular item of the troubleshooting chart, go directly to the referenced item. If no previous symptoms are known, begin with item 1 of the equipment performance check list in paragraph 2–10 and proceed until the trouble is located.

Caution: **If operational symptoms are not known, or the possibility of a short circuit exists within the Indicator, perform the short circuit checks described in *a* above, before applying power to the unit.**

(3) *Conditions for tests.* All checks outlined in the troubleshooting chart are to be conducted with the RF detector connected in a test configuration as described in *b* above and illustrated in figures 3–5 and 3–6. Refer to photographic views of the indicator to locate the stages and components listed in figure 3–8.

d. Troubleshooting Chart—RF Detector.

Item	Trouble	Probable cause	Remedy
1	Distorted or weak or no audio output (para 3–7*b* (5) (*c*)).	Defective transformer	Check T1. Replace.
		Defective component	Check C9, C10, L3, L4. Replace.
		Defective receptacle	Check J2. Repair or replace.
		Speaker voice coil open	Check. Replace speaker.
2	No 455-kc output at TP1 (para 3–7*b* (5) (*i*)).	Defective component in oscillator V1 stage.	Follow isolating procedures in para 3–7*e* to locate defective component. Replace.
3	433-kc oscillator cannot be be switched off (para 3–7*b* (5) (*j*)).	Mode switch defective	Check S2 on azimuth indicator. Replace.
		No relay excitation	Check continuity of relay excitation voltage lines.
		Defective relay	Check. Replace.
4	Improper limiting– excessive amplitude or frequency variations (para 3–7*b* (5) (*l*)).	Limiter stage not limiting or nonsymmetrical.	Examine output of each limiting stage working from back- to-front.
		Defective component	Follow isolating procedures in para 3–7*e* to locate defective component. Replace.
5	Limiting level too high or too low (para 3–7*b* (5) (*m*)).	Limiter stage not limiting at proper level.	Follow instructions in item 4 above. Look for insufficient or excessive limiting. Replace defective part.
6	Mixer (V12) output weak or nonexistent (para 3–7*b* (5) (*s*)).	Mixer stage V6 defective	Check for 555-kc output at TP4.
		Mixer stage V11 defective	Check for 550-kc output at TP8.
		Mixer stage V12A defective	Check for 5-kc output at V12A plate (pin 1). If any of above 3 outputs are nonexistent follow isolating procedures in para 3–7*e*
		Cathode follower stage V12B defective.	Check for 5-kc signal at input to filter FL1. Check, replace component.
		Defective filter	Check FL1. Replace.
7	DF level too low	Improper setting of df level control.	Adjust line to exactly 115 volts and adjust R89 for an exact 5.0 volts at TP11.

Item	Trouble	Probable cause	Remedy
		Amplifier stage defective.	Check stages V18A, V17, and V16 to locate faulty amplifier stage. Follow isolating procedures in para 3–7*e* to locate defective component.
		Defective filter	Check for excessive loss through filter stage comprehensive checks for filters follows in item No. 12.
8	Variation of DF output voltage (para 3–7*b* (5) (*x*).	Defective limiting stage	Check stages V15 and V14 for proper limiting and V13 for amplification. Follow isolating procedures in para 3–7*e* to locate defective component.
9	Harmonic distortion of DF signal (para 3–7*b* (5) (*y*)).	Defective harmonic filters	Check adjustment and performance of filters per paragraph 4–4. Replace defective unit.
10	Harmonic Distortion plus restricted DF signal (para 3–7*b* (5) (*z*)).	Defective harmonic filters and improper limiting.	Check adjustment and performance of filters per paragraph 4–4. Replace defective unit.
			Check for unsymmetrical limiting in stages V15 and V14. Perform isolating procedures in para 3–7*e* to locate defective component.
11	No or low aux. output (para 3–7*b* (5) (*aa*)).	Defective component	Check all elements from TP11 to J7 to locate defective component.
12	Poor harmonic rejection (para 3–7*b* (5) (*ac, ad*)).	Defective filter	Check rejection efficiency of filters. If less than required, replace.
		Defective component	Check all capacitors and resistors in filter circuit for defective part.

e. Isolating Troubles. When trouble has been localized to a stage through preceding operational and intraunit checks, use the following techniques to isolate the defective part.

(1) Test the tube involve, either in a tube tester (para 3–3*a*, item 8) or by substituting a similar type tube which is known to be functioning normally.

(2) Take voltage measurements at the tube socket using the voltage/resistance chart (fig. 6–13).

(3) Abnormal ac voltages are indicative of loss of signal or loss of stage gain. Open, leaky, or shorted capacitors are the most likely sources of trouble.

(4) Abnormal dc voltages are usually indicative of resistive changes in the stage. Take resistance measurements, using the voltage/resistance chart, to isolate the cause.

(5) If the directions (1) through (4) above do not uncover a defective part, turn to paragraph 4–4 for alignment instructions.

(6) Use schematic diagram for tracing signal flow and intercircuit measurements (fig. 6–18) and photographic presentation for physical location of parts (fig. 3–8).

3–8. RF Detector, Power Supply

a. Checking B+ and Filament Circuits for Shorts.

(1) *When to check.* When any of the following conditions apply, check for

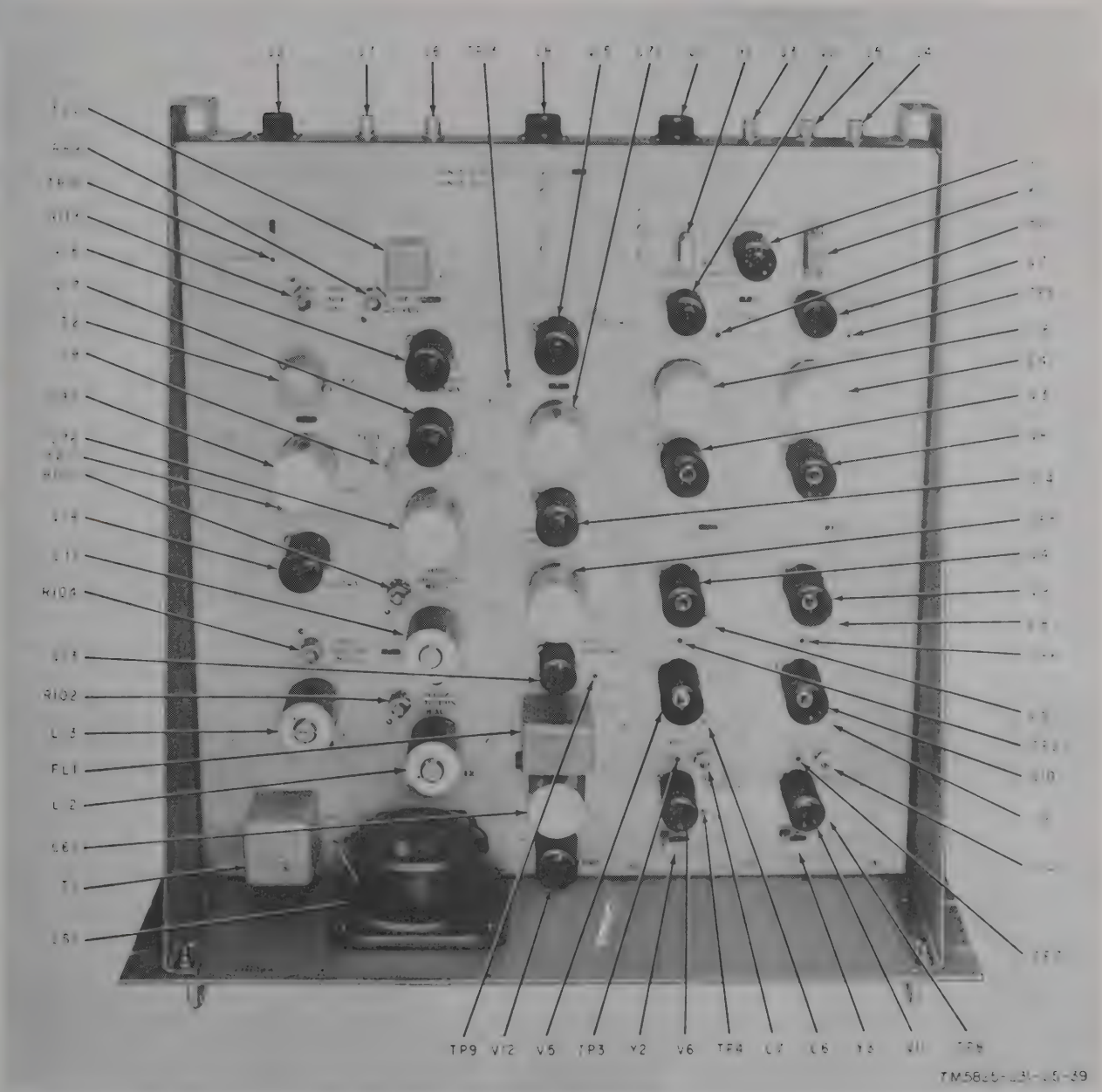

Figure 3–8 (1). RF detector, top view, location of parts.

shorted circuits and remove the trouble before applying power to the unit.

(*a*) When sectionalizing testing points toward power supply troubles.

(*b*) When operational reports indicate possible power supply problems.

(*c*) When unit is received for bench check with unknown symptoms.

(2) *Conditions for tests.* Perform the following steps in preparing for the short circuit tests.

(*a*) Disconnect cable connections to J1 through J4.

(*b*) Remove the power supply from the console.

(*c*) Set unit on bench preparatory to performing the tests in the chart in (*d*) below.

(*d*) A VOM (para 3–3*a*, item 26) is necessary for performing the resistance measurements required by the following test.

Short Circuit Tests—Power Supply, RF Detector

Test points	Resistance	Isolating procedure
TP1 to Ground	108K	Lower than normal resistance indicates— (1) *Breakdown of wiring insulation.* Check all B+ wiring and lead dress of components for possible short or arcover to ground (chassis). (2) *Component failure.* Remove control tube V2, amplifier tube V3, and reference tube V4, observing any significant change in B+ resistance to ground. Replace tube if a change is noted. Check capacitor C3 for leakage resistance and divider resistors for correct resistance value. Return tubes to sockets.
C1(+) to ground	----------	Lower than normal resistance indicates— (1) *Breakdown of wiring insulation.* Check all wiring in the rectifier, control, amplifier, and reference circuitry for possible shorts or arcover to ground. (2) *Component failure.* Remove rectifier tube V1, observing any significant change in resistance. Check capacitors C1 and C2 for leakage resistance. Check 5V filament winding for leakage to ground. Return tube to socket.
J1–A to ground	31K	Lower than normal resistance indicates— (1) *Breakdown of wiring insulation.* Visually inspect filament (6.3 V) wiring (2) *Component failure* Remove tubes V2 and V3 noting any significant change in resistance. Check transformer T1 for possible filament (6.3 V) winding leakage or short to the frame. Return tubes to sockets.

b. Bench Test Setup.

(1) Bench testing of the power supply, RF detector is required when inter-unit tests indicate that failure of system operation is due to a malfunction within the unit.

(2) Test equipment required.

Instrument	Mfr. code No.	Type or model No.
AC line meter	16902	49
Oscilloscope	80009	541
Test circuit, B+ voltage	92110	SCA535755–21B
Test circuit, filament voltage	92110	SCA535755–21A
Transformer, variable	58474	116
Volt-ohmmeter	16902	260

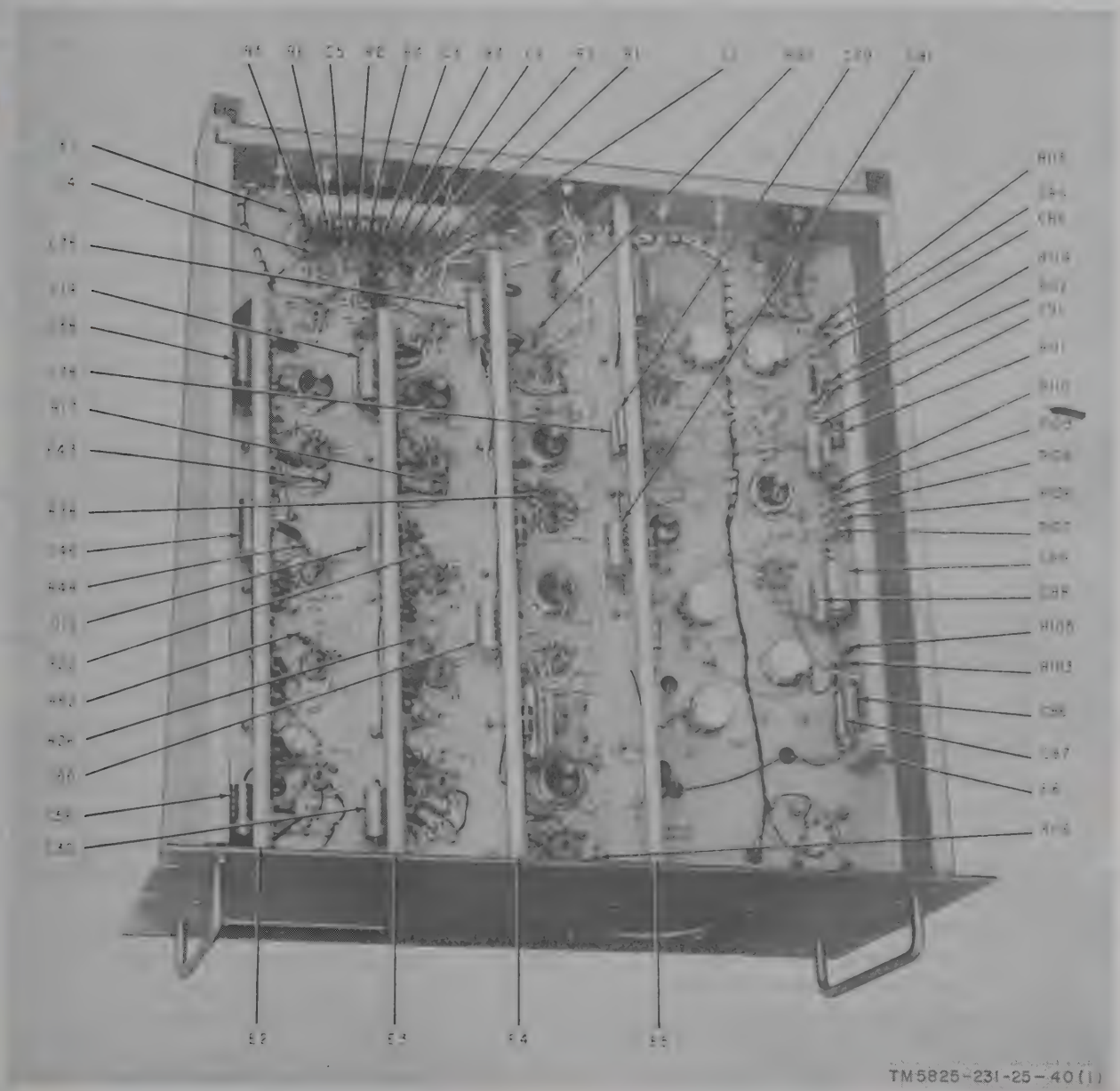

Figure 3–8 (2). RF detector, bottom view, location of parts.

(3) Connect the test equipment tabulated above in a test configuration as shown in figure 3–5.

(4) Construct a filament and a B +voltage test circuit as shown in figures 3–9 and 3–10, to bd used whenever the power supply is to be checked with proper loads applied.

(5) Bench test operation. Perform the following operations to simulate system operation of the RF detector power supply. When proper response to any of the steps below is not achieved, reference is made to the associated item in the troubleshooting chart.

(*a*) Connect the test setup shown in figures 3–9 and 3–10 to the POWER OUTPUT connector J2 of the power supply unit. Connect the VOM to the B+ test points shown in figure 3–10. Observe polarity and set the meter for DC (+) 400 volts. Close the B +test unit switch and open the filament test switch.

(*b*) Turn the power switch S1 on the power supply to the ON position and adjust the line to 115 volts by means of the variac. The B+ measured should be 250 ±2 volts dc. If not, see item 1 on the troubleshooting chart.

(*c*) Open the B+ test switch, noting that the voltage remains at 250 ±2 volts dc. If not, see item 2 on the troubleshooting chart.

(*d*) Change the line voltage to 125 volts and then to 105 volts, observing that the B+ remains at 250 ±2 volts dc. If not, see item 3 on the troubleshooting chart.

(*e*) Restore the line voltage to 115 volts, disconnect the Test Meter and connect it to the filament test points in figure 3–9. Adjust the meter for reading ac volts on the 10 volt scale. Read from 6.0 to 6.7 vac.

(*f*) Close the filament load switch, readjust the line voltage, if required, and observe a reading of from 5.8 to 6.5 vac.

(*g*) Increase the line voltage to 125 volts and observe a reading of from 6.3 to 6.8 vac.

(*h*) Reduce the line voltage to 105 volts noting that the voltage is between 5.1 and 5.9 vac. If satisfactory voltages cannot be obtained in (*e*) through (*g*) above refer to item 4 in the troubleshooting chart.

(*i*) Restore line voltage to 115 volts and remove the VOM. Leaving the test load connected and both load switches off, insert the probe of the oscilloscope into TP1 on the power supply. Measure the peak-to-peak amplitude of hum and noise present. Adjust R2, HUM BALANCE, if necessary to satisfy the requirements of 0.25 volt peak-to-peak as the maximum acceptable value. If not attainable, refer to troubleshooting chart, item 5.

(*j*) Shut off power and remove test setup.

c. Localizing Troubles.

(1) *General.* Procedures are outlined in *d* below for localizing troubles to a particular section or stage within the RF detector power supply. With the use of normal troubleshooting techniques and the voltage resistance chart (fig. 6–9) the trouble can be isolated to a particular part.

(2) *Use of chart.* The troubleshooting chart is designed to supplement operational checks performed as directed in chapter 2 and the interunit sectionalization checks described in paragraph 3–4. If previous operational or sectionalization checks have resulted in reference to a particular item of the troubleshooting chart, go directly to the referenced item. If no previous symptoms are known begin with item 1 of the equipment performance checklist in chapter 2 (para 2–10.) and proceed until the trouble is located.

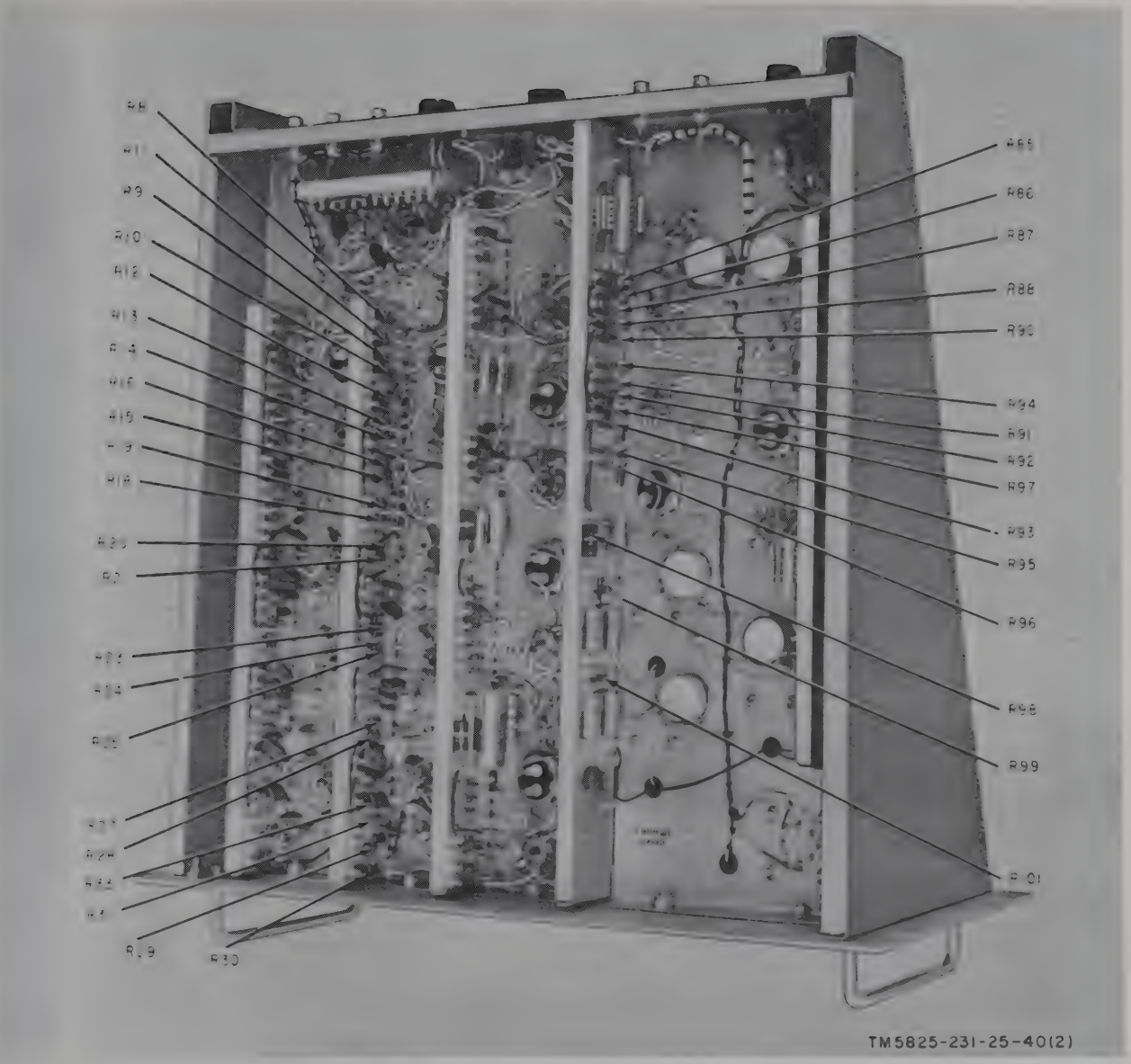

Figure 3–8 (3). RF detector, bottom view, location of parts.

Caution: **If operational symptoms are not known, or the possibility of a short circuit exists within the power supply, perform the short circuit checks described in *a* above before applying power to the unit.**

(3) Conditions for tests. All checks outlined in the troubleshooting chart are to be conducted with the RF detector power supply connected in a test configuration as described in paragraph 3–8 *b* and illustrated in figures 3–5, 3–9, and 3–10. Refer to photographic views of the power supply to locate the stages and components listed (fig. 3–11).

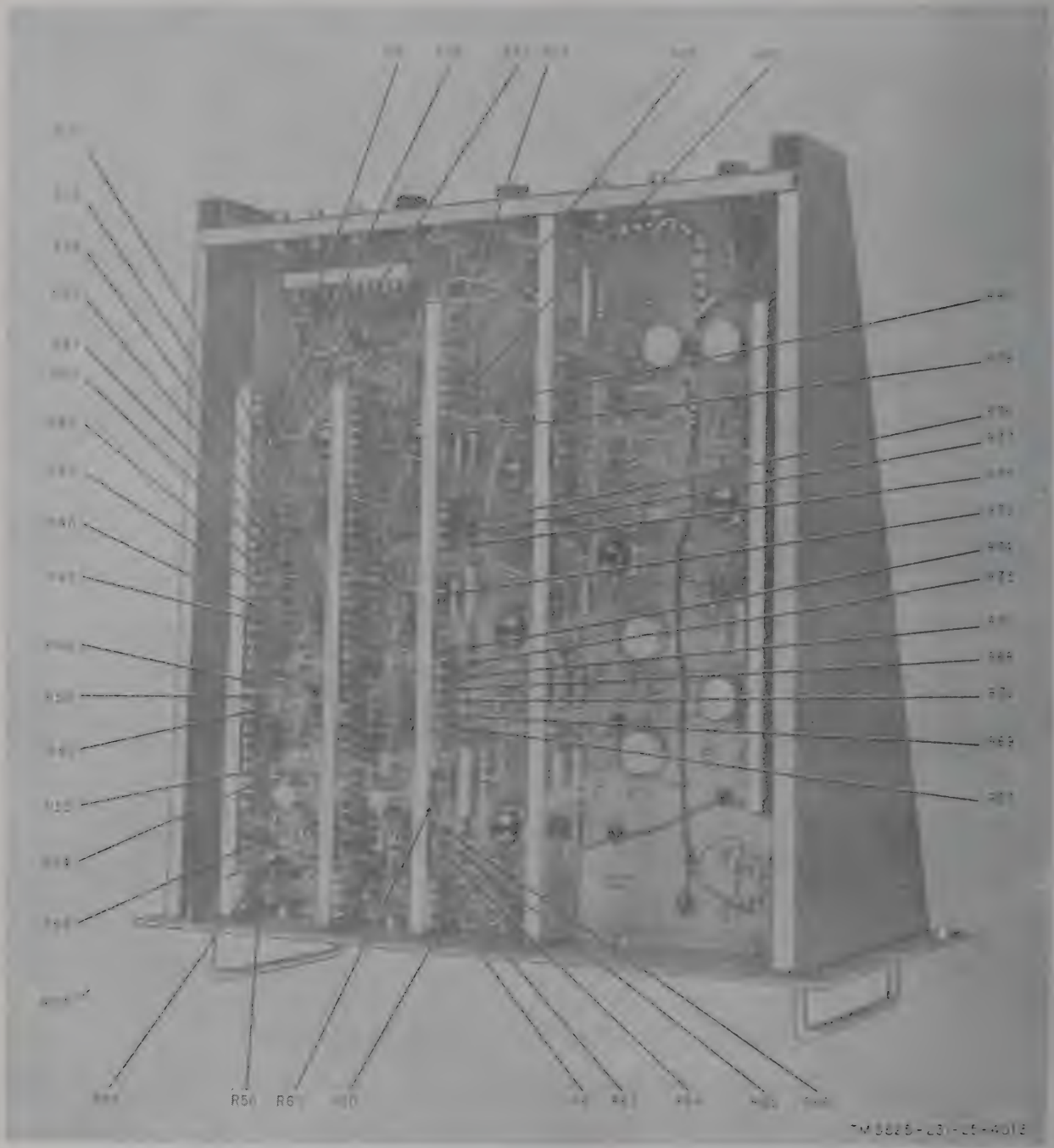

Figure 3–8 (4). RF detector, bottom view, location of parts.

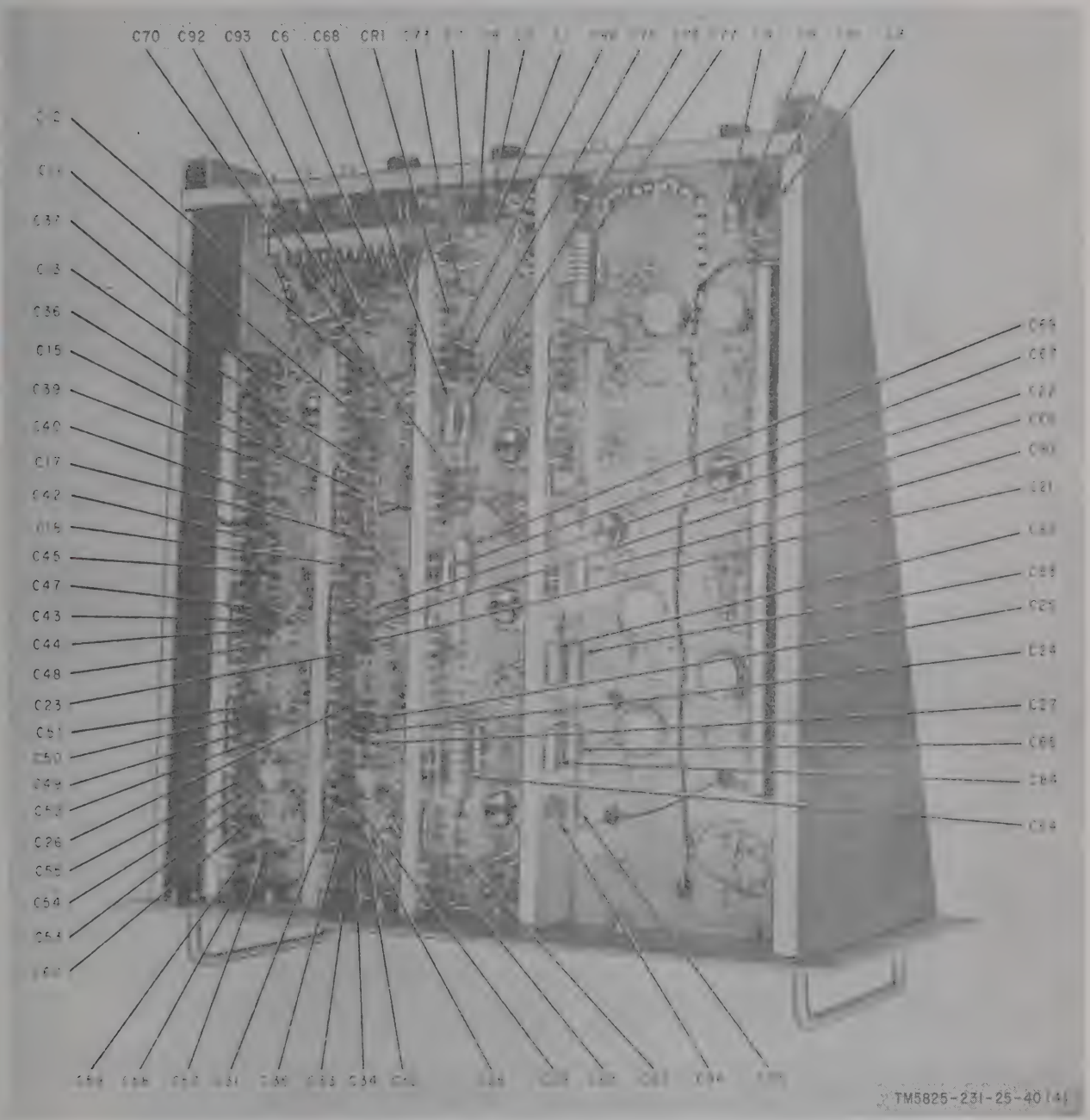

Figure 3–8 (5). RF detector, bottom view, location of parts.

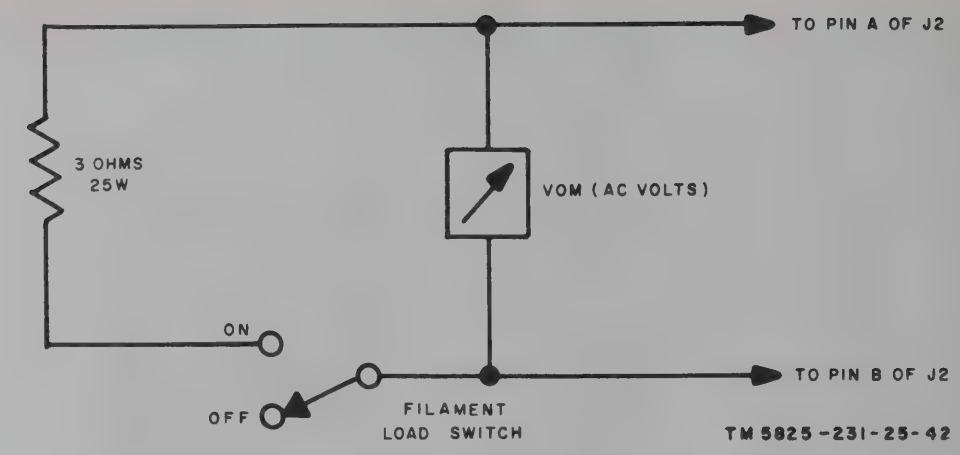

Figure 3–9. Filament voltage test circuit.

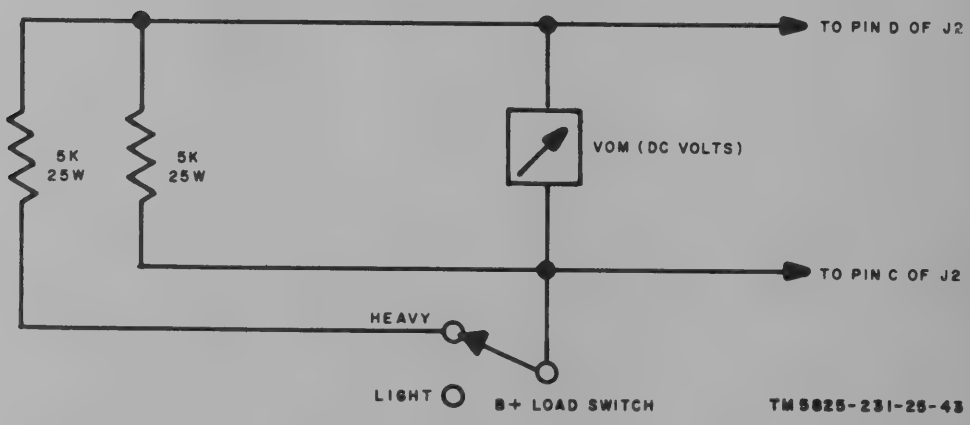

Figure 3–10. B+ voltage test circuit.

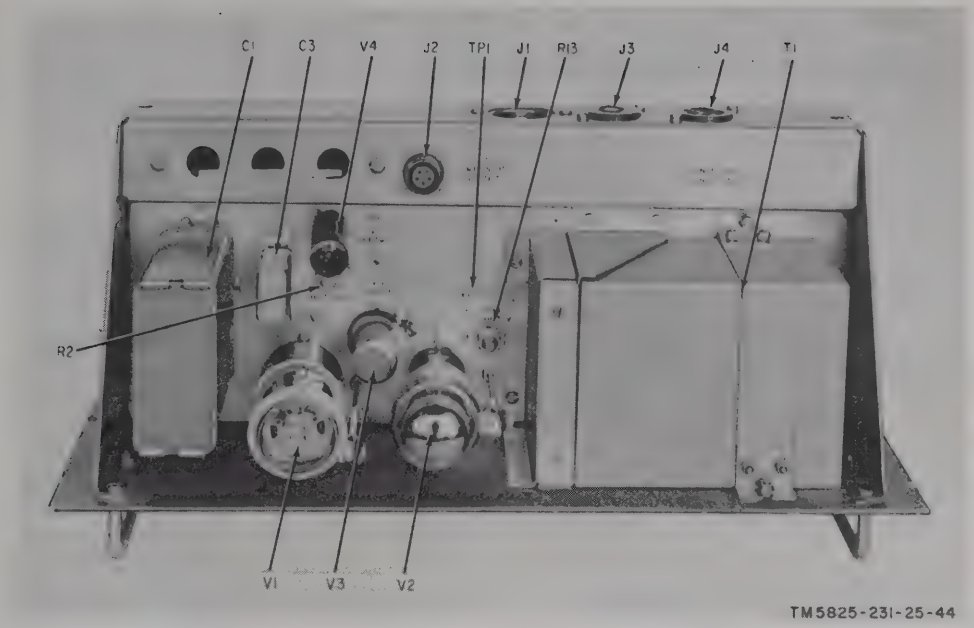

Figure 3–11 (1). RF detector power supply, top view, location of parts.

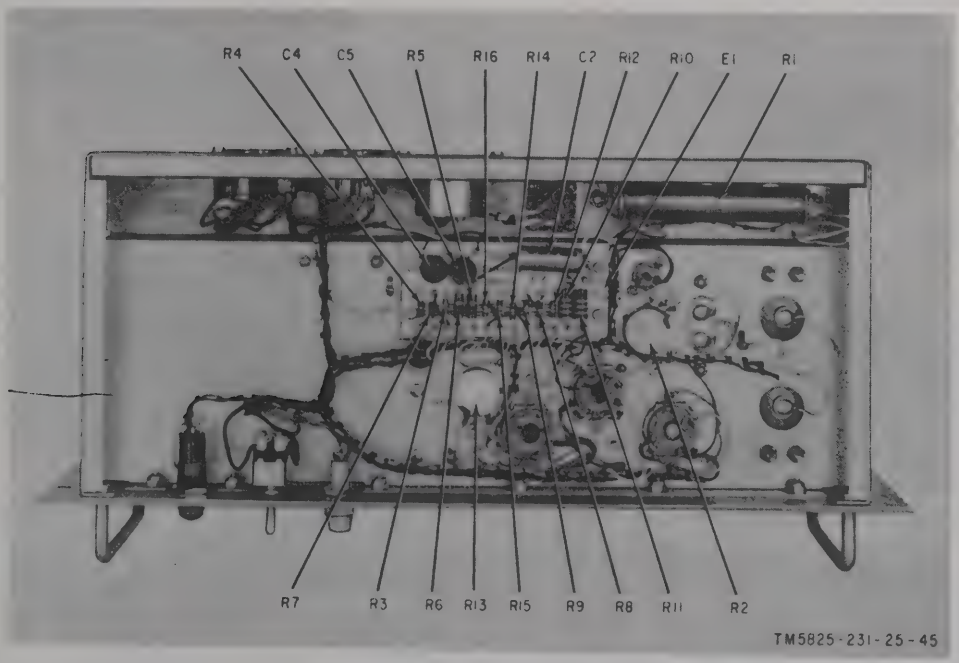

Figure 3–11 (2). RF detector power supply, bottom view, location of parts.

d. Troubleshooting Chart—Power Supply, RF Detector.

Item	Trouble	Probable cause	Remedy
1	B+ voltage out of tolerance 250±2 VDC.	Misadjustment of or defective output voltage control R14.	Adjust R14, If no response, check for shorted or open control. Replace.

Item	Trouble	Probable cause	Remedy
		Defective component	Check control, amplifier, and rectifier stages by following procedure described in para 3–8*e* to isolate trouble to a component. Replace.
2	B+ voltage varies with load change.	Control stage V2 not operating properly.	Follow isolating procedures in para 3–8*e* to locate defective component. Replace.
3	B+ voltage varies	Amplifier reference stage V3, V4 not performing properly.	Follow isolating procedures in para 3–8*e* to locate defective component. Replace.
4	Filament voltage out of tolerance.	Defective transformer.	If, after 20 min of operation, transformer becomes too hot to touch, internal short exists. Check, replace.
			If no overheating exists, but voltage is low, perform no load primary power test. If above mfr's rating, replace.
5	Excessive hum, ripple, noise.	Defective or misadjusted control	If no adjustment improves hum balance, check control R2, replace.
		Amplifier stage V3 not operating properly.	If best adjustment does not reduce hum sufficiently, follow isolating procedures in *e* below to isolate component. Replace. Check C2 (sampling capacitor) in hum balance circuit. Replace if defective.

e. Isolating Troubles. When trouble has been localized to a stage through preceding operational and intraunit checks, use the following techniques to isolate the defective part:

(1) Test the tube involved, either in a tube tester (para 3–3*a*, item 22) or by substituting a similar type tube which is known to be functioning normally.

(2) Take voltage measurements at the tube socket using the voltage/resistance chart (fig. 6–9).

(3) Abnormal ac voltages are indicative of loss of signal or loss of stage gain. Open, leaky, or shorted capacitors are the most likely sources of trouble.

(4) Abnormal dc voltages are usually indicative of resistive changes in the stage. Take resistance measurements, using the voltage/resistance chart, to isolate the cause.

(5) If the directions in (1) through (4) above do not uncover a defective part, refer to paragraph 4–4*c* for alignment instructions.

(6) Use schematic diagram for tracing signal flow and intercircuit measurements, (fig. 6–15) and photographic presentation for physical location of parts (fig. 3–1).

3–9. Radio Receiver R 725/URR (Modified Version of Radio Receiver 390A/URR)

a. Modification Data. Radio Receiver R390-A/URR has been modified in the following manner. These modifications have resulted in upgrading this receiver to Radio Receiver R–725/URR for use as part of Direction Finder Set AN/TRD–15.

(1) Replaced IF subchassis to improve performance when receiver is used in conjunction with direction finding equipment.

(2) Completed the following wiring modifications to reduce hum. Number 22 AWG wire was used for all connections (fig. 6–5).

(*a*) Open small inclosure at end of VFO unit and lift pin 3 of V701 from ground.

(*b*) Connect a capacitor (CK63AW103-M) between V701–3 and ground.

(*c*) Connect V701–3 to J709–C. Solder connections and close up VFO.

(*d*) Connect P109–C to P121–E (filament return).

(*e*) Disconnect and dead end wire from P112–8.

(*f*) Connect P112–8 to P121–F (filament supply).

(*g*) Parallel connect a wire from P111–7 to P121–A (primary supply).

(*h*) Parallel connect a wire from P-111–6 to P121–B (primary supply).

(*i*) Parallel connect a wire from P119–2 to P121–C (B+ supply).

(*j*) Connect a wire from P121–D to chassis ground.

(3) Results of wiring modification. See figure 61 (TM 5820–358–35–65) in TM 11–5820–358–35. Filament voltage of the VFO from V701–3 to ground now measures 25 volts DC. Resistance from V701–3 to ground now measures 33 k. These are the only voltages/resistance changes caused by the wiring modification described in (2) above.

b. Checking B+ Voltages for Shorts. These procedures should be followed when any of the following conditions exist, and are adequately covered in paragraph 41 of TM 11–5820–358–35, except that resistance from J512–2 to ground is 35 K.

(1) Sectionalized analysis indicates power supply trouble.

(2) Operational reports indicate power problems.

(3) Unit is received for bench check and repair without description of malfunction.

c. Bench Test Procedures. Procedures for the R725 receiver are described in chapter 2, section II of TM 11–5820–358–35. Follow normal procedures for testing the receiver as outlined in this section, except for the following:

(1) IF troubleshooting chart *d* below, is substituted for troubleshooting chart in paragraph 46*d*(3) of TM 11–5820–358–35.

(2) Component identification is accomplished by referring to IF subchassis bottom views in figure 3–12.

(3) Tube voltage and resistance diagram, IF subchassis, voltage and resistance diagram, figure 60 (TM 5820–358–35–64) in TM 11–5820–358–35.

(4) Substitute IF stage gain test (*e* below) for IF test, paragraph 48*b* of TM 11–5820–358–35.

(5) Paragraph 49 *d*, of TM 11–5820–358–35 is not applicable to these procedures.

d. The IF Subchassis. The troubleshooting chart below outlines procedures for localizing troubles to a stage in the IF subchassis, and indicates probable cause and recommended solutions. If recommended solution does not solve problem, make voltage and resistance checks in accordance with figure 6–10 and correct deficiency.

Item	Trouble	Probable cause	Remedy
1	No signal or weak signal when af signal is applied to pins 1 and 2 of tube socket XV510, anode of positive peak limiter.	Capacitor C529, V510	Check circuit components and replace defective part.
2	Weak signal output when af signal is applied to pin 3 of tube socket XV-510, cathode of positive-peak limiter.	V510 defective or R542, R544 open.	Check and replace component if defective.

Item	Trouble	Probable cause	Remedy
3	Weak signal output when af signal is applied to pins 6 and 7 of tube socket XV507, anode of negative-peak limiter.	V507 or R541 defective.	Replace defective component.
4	Weak or no output signal when 455-kc modulated signal is applied at pins 1 and 2 of tube socket XV507, anode of detector.	Defective tube or loose jumper between terminals 14 and 15 of rear terminal strip.	Tighten terminal 14 and 15 jumper connections and replace V507 if defective. If trouble persists, check voltage and resistance of circuit components.
5	Weak cutput when 455-kc modulated signal is applied to pin 5 of tube socket XV506, plate of sixth I.F. amplifier.	T506 open or shorted or not properly aligned.	Check and replace T506 if open or shorted. For alignment refer to chapter 4.
6	Apply 455-kc modulated signal to pin 1 of V506, grid of 6th I. F. amplifier. Output should be somewhat louder than in Step 5.	Open C523 or C524, or defective tube.	Shunt capacitors with ones of like value and replace if defective. Check V506.
7	IF subchassis still defective.	Defective IF stage_____	Refer to para 3–9*e* for IF stage gain test and replace defective component.

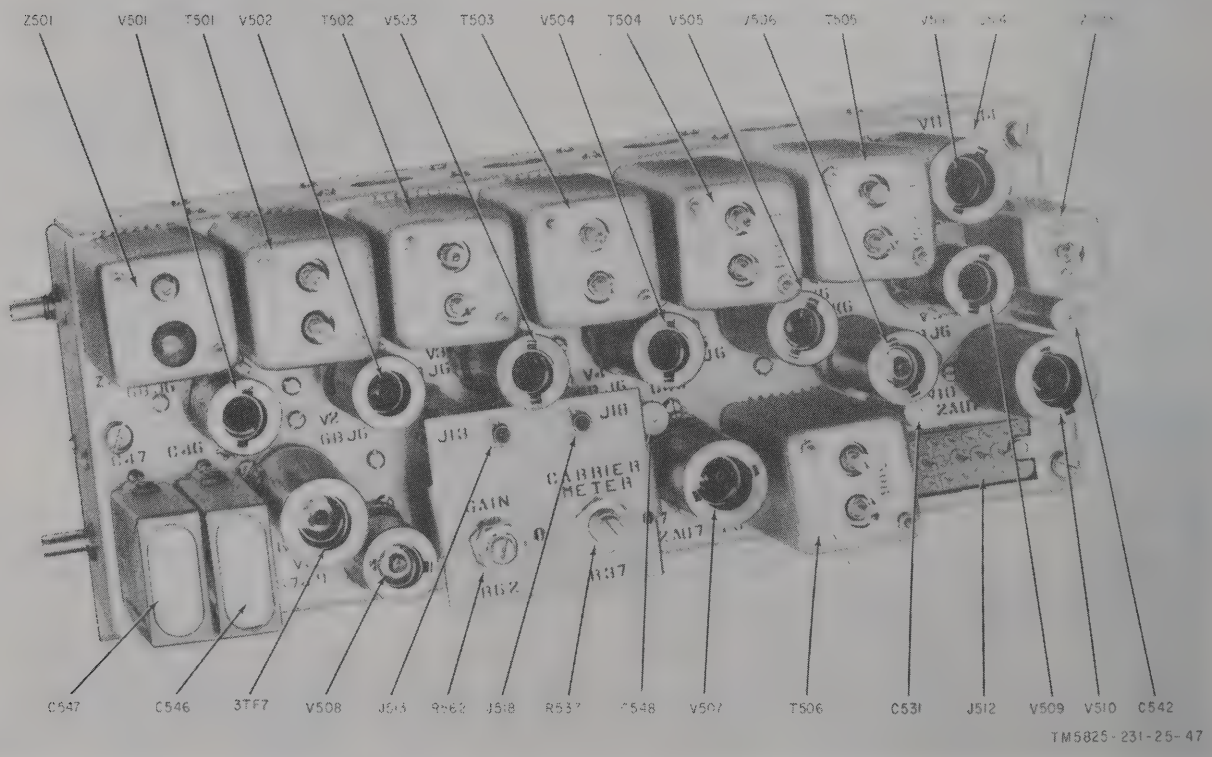

Figure 3–12 (1). IF Subchassis, top view, location of parts.

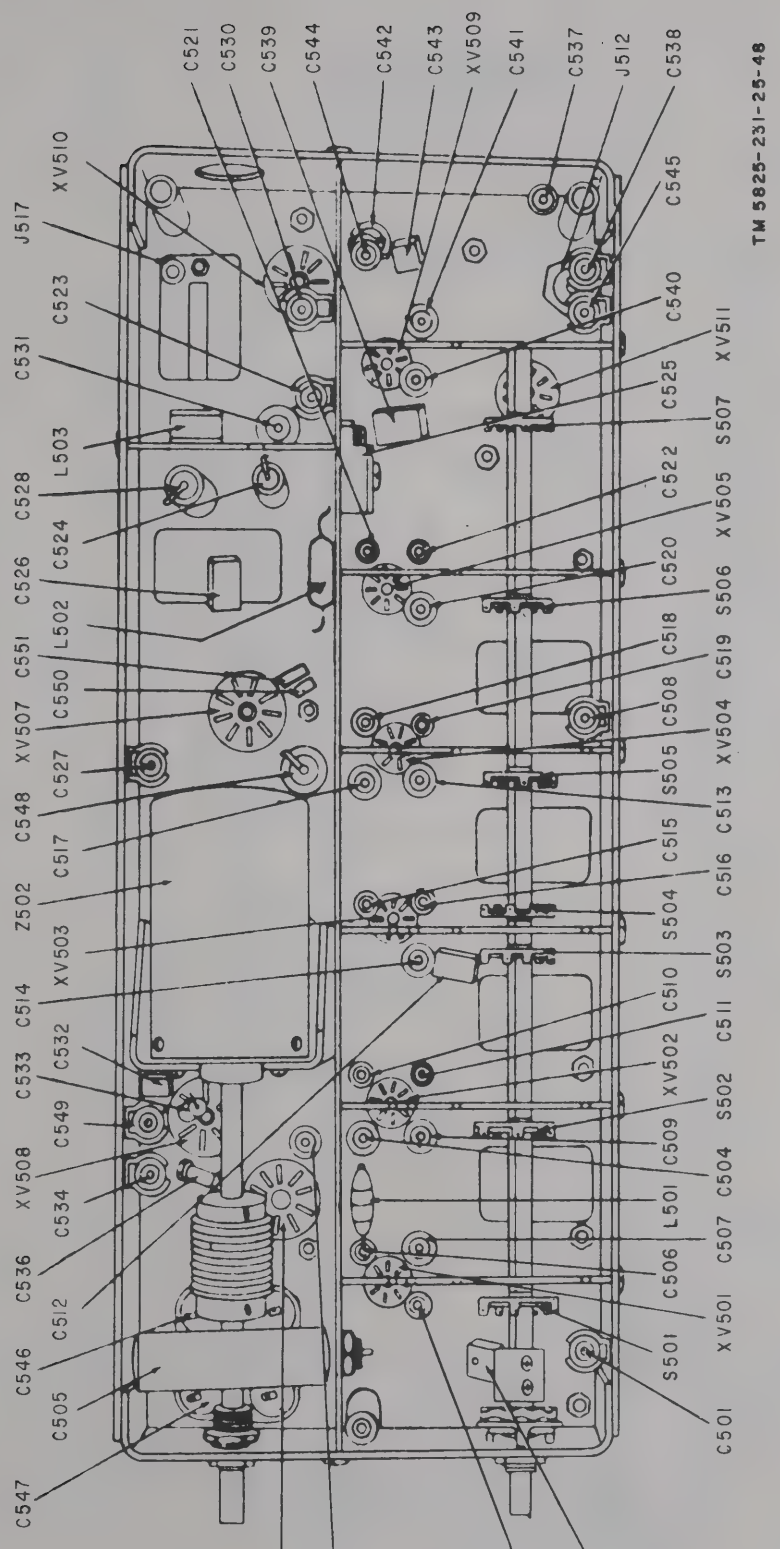

Figure 3-12 (2). IF Subchassis, bottom view, location of parts.

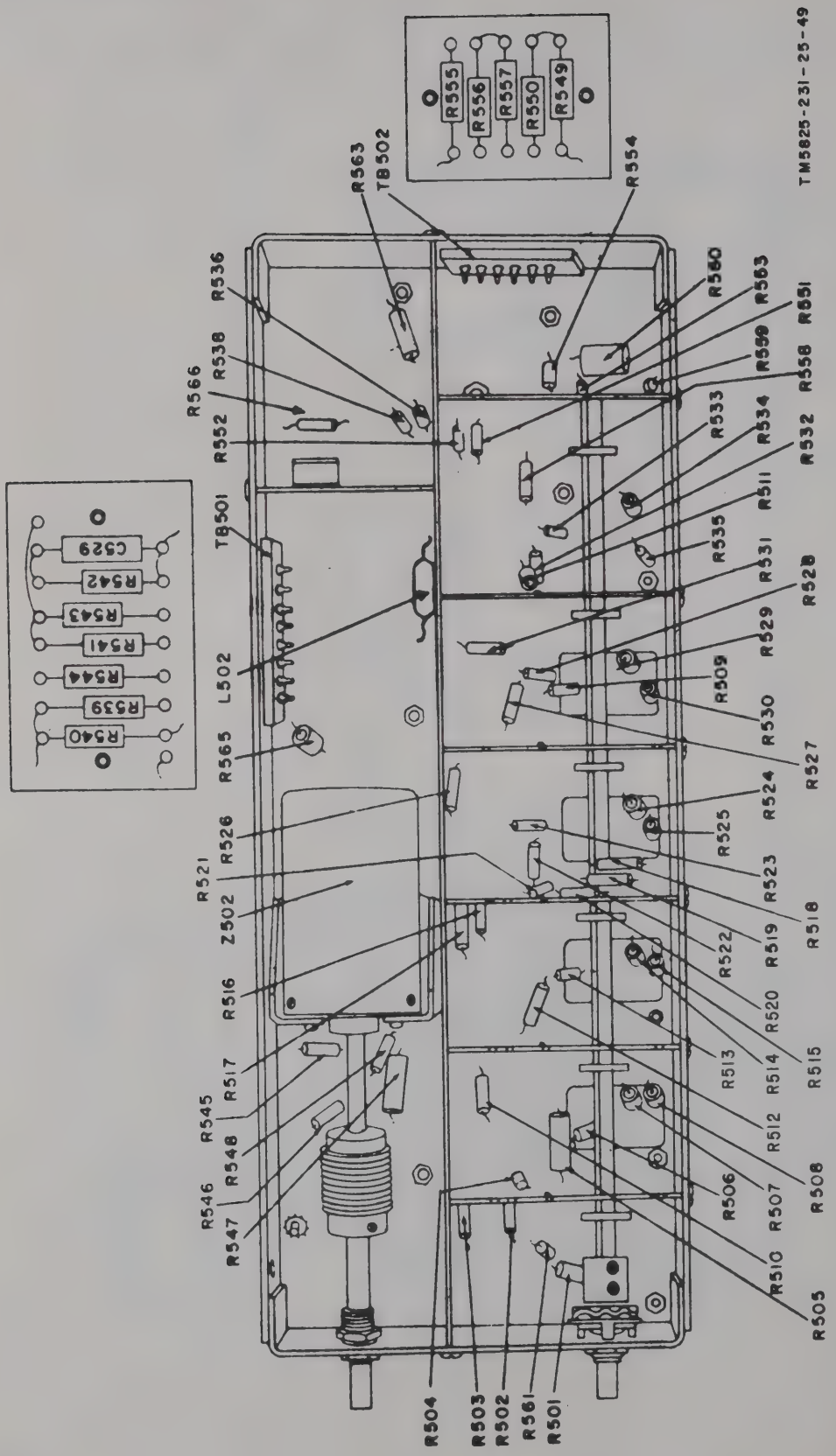

Figure 3–12 (2). IF Subchassis, bottom view, location of resistors.

e. IF Stage Gain Test. This test supplements paragraph 45 of TM 11–5820–358–35, and will indicate trouble in the first six stages of the IF subchassis. In the event a stage reads outside charted values, replace faulty component before proceding to next stage.

(1) The stage gain chart below lists the minimum and maximum voltages required at each of the IF stages of the receiver to produce a voltage of –7 volts dc across the diode load. Use this chart as a standard when troubleshooting to check the gain of each IF stage or group of stages. When the receiver output is low and the tubes are operating satisfactorily (as indicated by a tube checker), localize the defective stage by checking the signal voltage level of each stage against the chart while using the signal substitution method of troubleshooting, or by measuring the individual stage gain.

(2) To obtain the stage gain readings, connect a dc voltmeter such as the 260 VOM, between terminals 14 (DIODE LOAD) and 16 (GND) of the terminal strip on the back of the receiver. Terminal 14 must be jumpered to terminal 15. Connect the ground lead of the RF signal generator to the receiver ground, and connect the generator output lead through a .1 μf capacitor to the receiver points indicated in the chart. When checking the 455-kc IF stages, access to the injection points can be gained by operating the subchassis outside the receiver, using the extension cables, or by inserting a short length of wire into the tube socket terminal. Check the output from the signal generator required to obtain the diode load reference voltage of –7 volts dc against the figures given in the charts. The lowest figure is the minimum and the highest is the maximum that should be required over the specified frequency range for normal operation. However, a reading that is slightly outside this range does not necessarily indicate improper functioning.

IF Subchassis Stages—Signal Generator Output (Microvolts)

Signal generator output connection	2-kc bandwidth	4-kc bandwidth	8-kc bandwidth	16-kc bandwidth
1st if grid V501.	130 to 180			
2nd if grid V502.	1,500 to 1,900	1,400 to 2,000	880 to 1,400	860 to 1,700
3rd if grid V503.	2,300 to 5,000	3,000 to 5,000	1,100 to 2,000	770 to 1,300
4th if grid V504.	7,000 to 12,000	7,000 to 11,500	6,000 to 8,700	5,200 to 7,600
5th if grid V505.	16,000 to 20,000	16,000 to 18,000	23,000 to 28,000	32,000 to 38,000
6th if grid V506.	420,000 to 500,000	420,000 to 500,000	420,000 to 500,000	420,000 to 500,000

3–10. Goniometer - Rotary Coupler

a. Troubleshooting of this unit by direct support maintenance personnel should be limited to the following:

(1) Orientation or indexing of goniometers as described in TM 11–5825–231–10, paragraph 2–21.

(2) Removal and replacement of the drive, goniometer-rotary coupler chassis.

(3) Checking, repairing, and replacing malfunctioning components in the relay switching area only (fig. 3–13).

b. Malfunctions in the DF/(audio) MONITOR receiver mode switching relays are indicated in *d* below.

c. Voltage/resistance measurements are shown in the schematic (fig. 6–19) for both functional areas. If there are any reasons to suspect shorting circuits, visual inspection of the unit should be made in addition to routine resistance checks.

d. Troubleshooting chart, DF/(audio) MONITOR mode receiver relay switching, (part of drive, goniometer-rotary coupler.

Item	Trouble	Probable cause	Remedy
1	No DF or audio DF with MONITOR switch in DF position on primary receiver. Sense pattern proper.	Relay K1 closed and inoperative	Replace K1.
2	No MONITOR audio with switch in MONITOR position on primary receiver.	K2 inoperative	Replace K2.
3	Cannot obtain MONITOR AUDIO, DF operates, switch in MONITOR position.	K1 and K2 inoperative	Check 6.3 VAC from primary indicator, open CR3 or shorted C4.
4	Noisy audio with DF/MONITOR switch in MONITOR position	K1 inoperative	Check and replace K1.

Note. The same troubles can occur to receiver number two DF/MONITOR switching relays K3 and K4.

3–11. Amplifer, Electronic Control

a. Checking B+ Circuits for Shorts.

(1) *When to check.* When any of the following conditions apply, check for shorted circuits and remove the trouble before applying power to the unit.

(*a*) When sectionalizing testing points toward power supply troubles.

(*b*) When operational reports indicate possible power supply problems.

(*c*) When unit is received for bench check with unknown symptoms.

(2) *Conditions for tests.* Perform the following steps in preparing for the short circuit tests.

(*a*) Disconnect cable connections to J1 and J2.

(*b*) Remove the amplifier unit from the console.

(*c*) Invert unit on bench preparatory to performing the tests in (*d*) below.

(*d*) A VOM (para 3–3*a*, item 26) is necessary for performing the resistance measurements required by the following test:

Caution: **When measuring resistance in transistorized circuitry be certain that the (+) meter lead is attached to the B+ and the (–) meter lead to ground.**

Short Circuit Tests—Amplifier, Electronic Control

Test points	Resistance	Isolating procedure
C11(+) to ground (unregulated B+).	10 ohms	A high resistance indicates— (1) Open load resistor, R27. Replace. (2) Broken lead. Repair. A low resistance indicates— (1) Shorted diode CR8, CR9. Replace. (2) Shorted capacitor C10, C11. Replace. (3) Shorted transistor, Q4 thru Q9. Replace. (4) Shorted wiring. Repair.
XMP1–7 to ground (MP1 removed from socket).	640 ohms	A higher resistance indicates— (1) One of divider resistors is open. Replace. (2) Broken lead. Repair. A lower resistance indicates— (1) One of the transistors is shorted. Replace. (2) Wiring short. Repair.

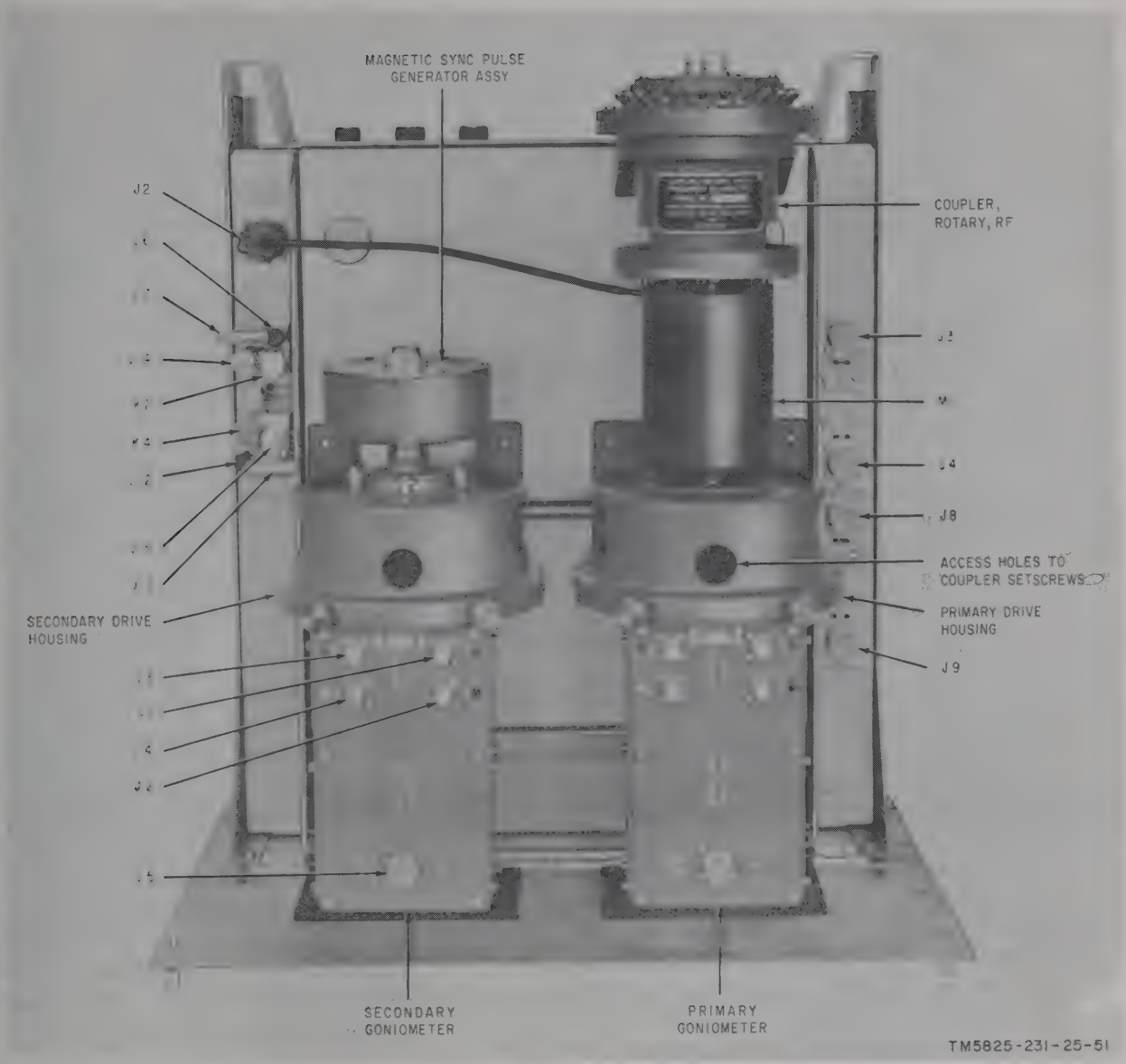

Figure 3–13 (1). Drive, goniometer-rotary coupler, top view, location of parts.

b. Bench Test Setup.

(1) Bench testing of the electronic control amplifier is required when inter-unit tests indicate that failure of system operation is due to a malfunction within the unit.

(2) Test equipment required.

Instrument	Mfr. code No.	Type/ model No.
AC line meter	16902	49
Drive, goniometer-rotary coupler.	92110	TG-126/TRD
*Electronic control amplifier.	92110	AM3545/TRD
Frequency counter	80740	7370
Oscilloscope	80009	541
Variac	58474	136

(3) Connect the test equipment tabulated in the chart above in a test arrangement as shown in figure 3–4.

(4) The Gonio drive motor is a necessary part of this test setup since its driving speed is determined by the prop-

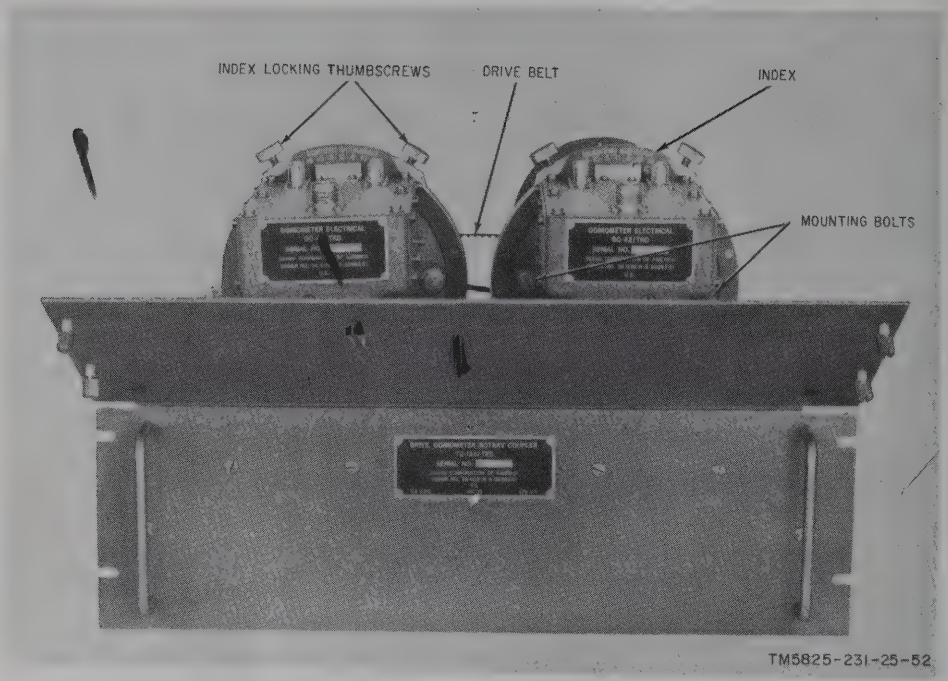

Figure 3–13 (2). Drive, goniometer-rotary coupler, front view, location of parts.

er functioning of the amplifier to supply sufficient power at a controlled frequency. Amplifier frequency and motor synchronization will be checked to determine satisfactory operation of the electronic control amplifier.

(5) Perform the following operations to simulate system operation of the electronic control amplifier in a bench test setup. When proper response to any of the steps below is not achieved, reference is made to the associated item in the troubleshooting chart.

(*a*) Adjust line voltage to 115 volts, turn on the unit, and after the drive motor is up to "sync" speed, trim line voltage to maintain 115 volts as read on the AC line meter.

(*b*) Connect the counter (7370) to TP10 on the amplifier chassis. With the counter adjusted to read the period of the signal, the display should fall between 555.77 and 5558.33 microseconds. If not, refer to item 1 in the troubleshooting chart.

(*c*) Adjust the line voltage to the extremes of 105 and 125 volts noting that the reading of the period of the signal remains within 5552. 77 to 5558.33 microseconds. If not, refer to item 2 of the troubleshooting chart.

(*d*) Connect sync pulse output from J1 of the Gonio drive unit to the trigger input and one of the vertical inputs of the oscilloscope. Adjust scope so that two "sync" pulses are displayed.

(*e*) Connect output of amplifier at T3–7 via a 10:1 probe to the second vertical scope input. When the Gonio drive motor is in "sync", the signals displayed on separate traces will stand still with respect to each other. If not, refer to item 3 of the troubleshooting chart.

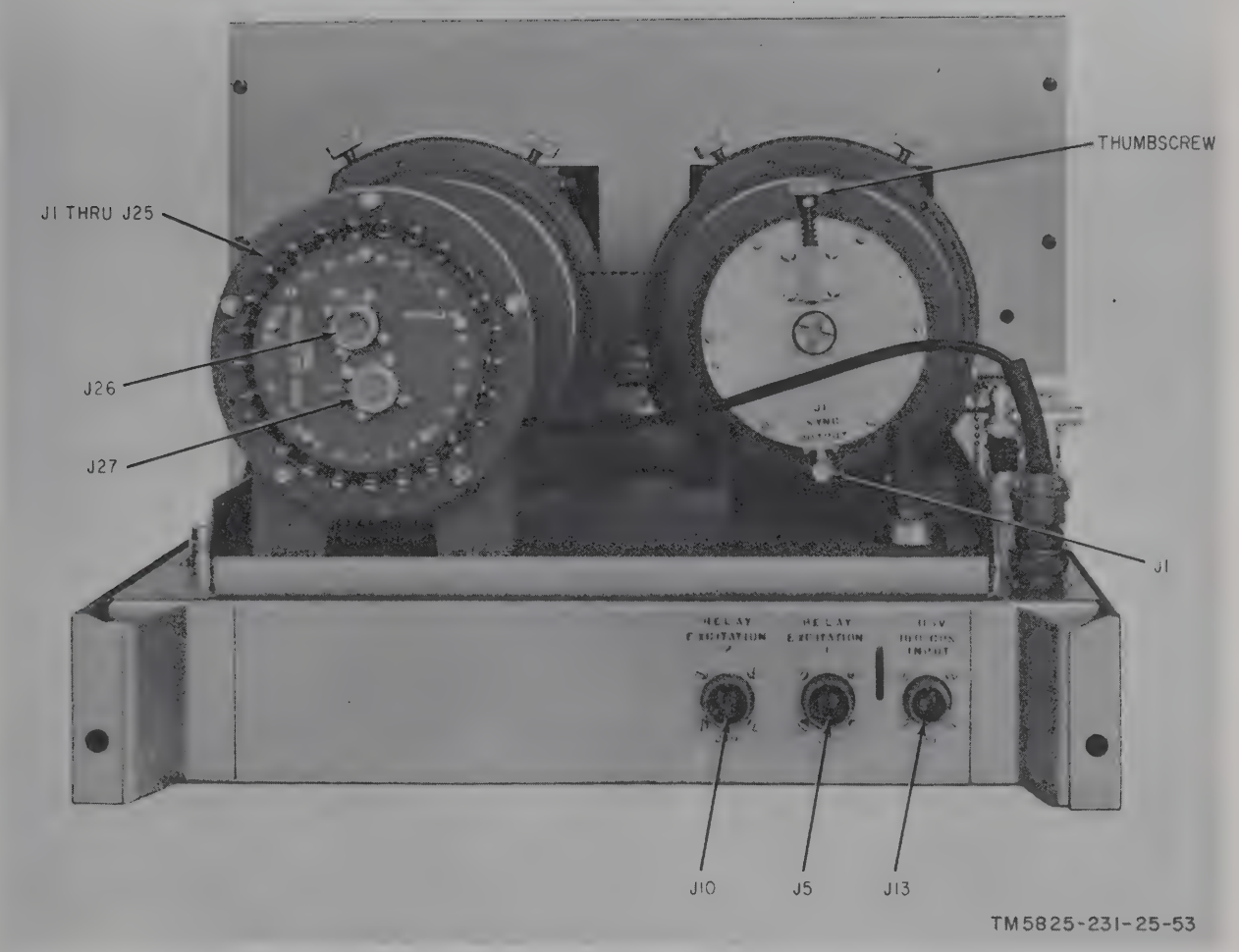

Figure 3–13 (3). Drive, goniometer-rotary coupler, rear view, location of parts.

(*f*) Turn off the electronic control amplifier. Readjust line voltage first 105 and then 125 volts, noting that each time the amplifier is turned on the conditions required in (*e*) above are met. If not, refer to item 3 of the troubleshooting chart.

c. Localizing Troubles.

(1) *General.* Procedures are outlined in *d* below for localizing troubles to a particular section or stage within the Electronic Control Amplifier with the use of normal troubleshooting techniques and the voltage charts which follow, the trouble can be isolated to a particular part.

(2) *Use of chart.* The troubleshooting chart is designed to supplement operational checks performed as directed in chapter 2 and the interunit sectionalization checks described in paragraph 3–4. If previous operational or sectionalization checks have resulted in reference to a particular item of the troubleshooting chart, go directly to the referenced item. If no previous symptoms are known, begin with item 1 of the equipment performance checklist in (paragraph 2–

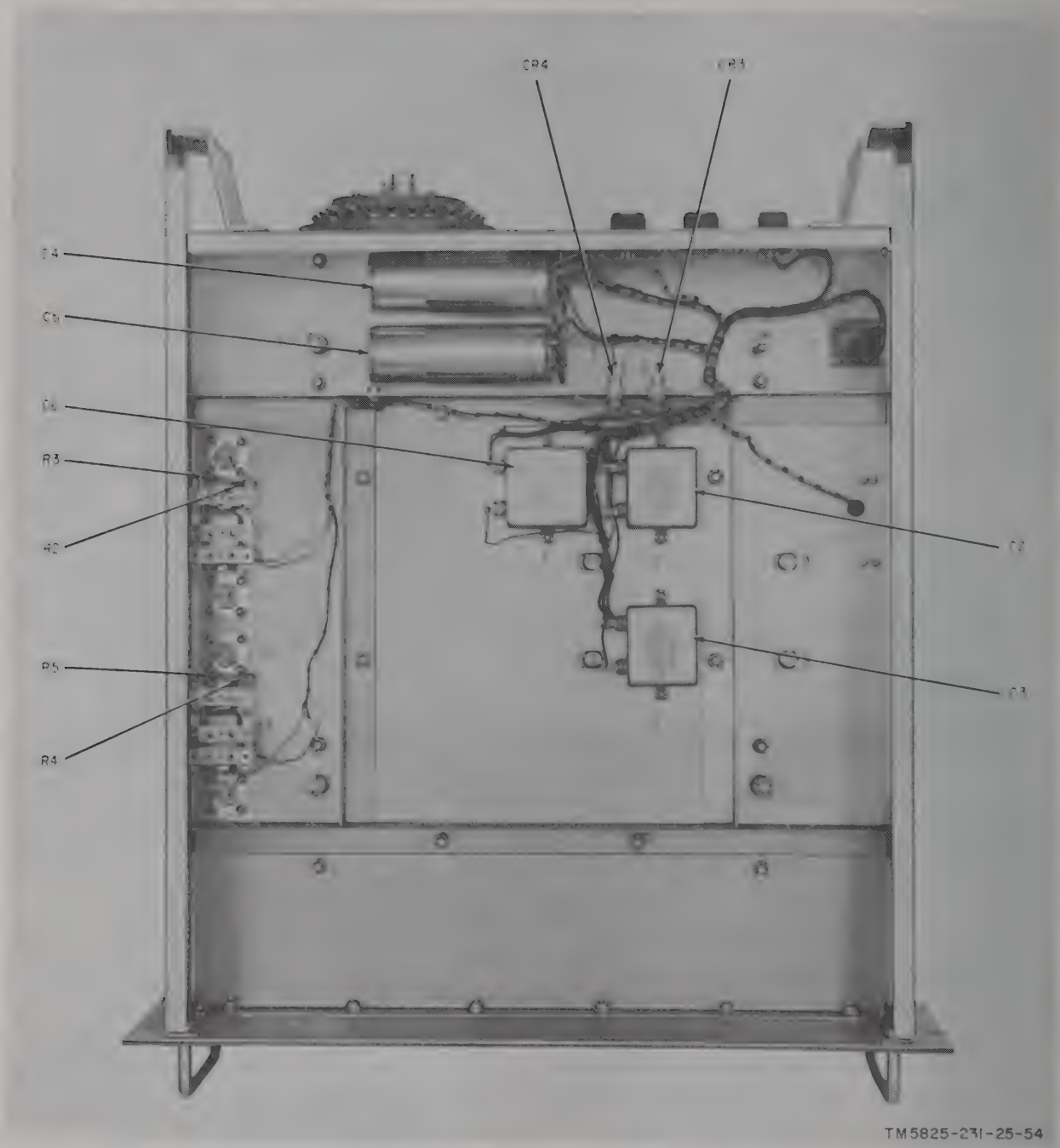

Figure 3–13. (4). Drive, goniometer-rotary coupler, bottom view, location of parts.

10 and proceed until the trouble is located.

Caution: **If operational symptoms are not known, or the possibility for short circuit exists within the amplifier, perform the short circuit checks described in paragraph 3–10*a* before applying power to the unit.**

(3) *Conditions for tests.* All checks outlined in the troubleshooting chart are

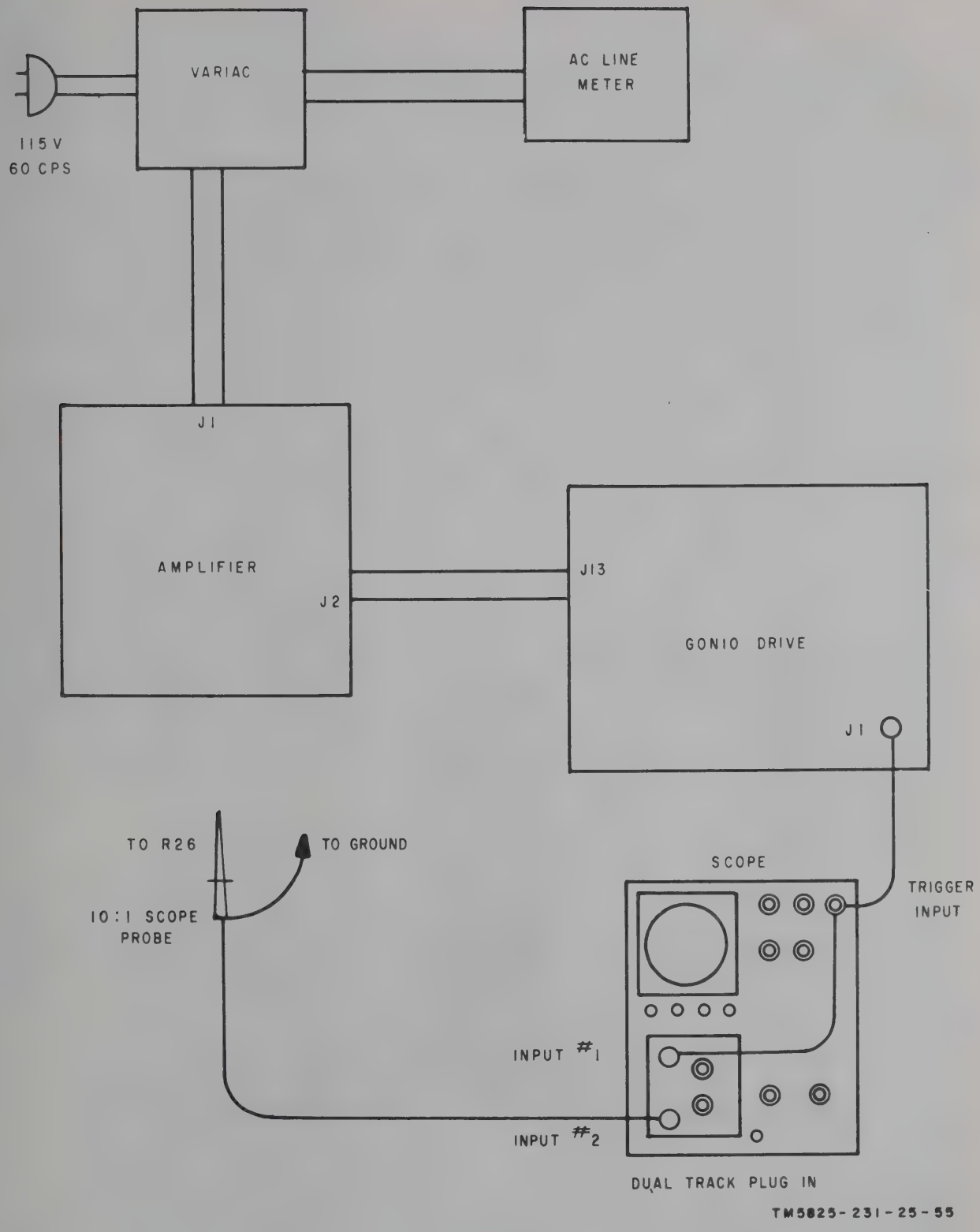

Figure 3–14. Test setup, electronic control amplifier.

to be conducted with the amplifier connected in a test configuration as described in paragraph 3–10*b* and illustrated in figure 3–14. Refer to photographic views of the amplifier to locate the stages and the components listed in figure 3–15 (1), (2), (3).

d. Electronic Control Amplifier.

Item	Trouble	Probable cause	Remedy
1	Incorrect frequency_____	Defective tuning fork_____	Unplug MP1 and replace.
2	Frequency varies with line voltage change.	Power supply to fork not regulating.	Check for defective component in Q10 regulator stage.
3	Motor does not"sync" with amplifier frequency.	Insufficient drive power _____	Check amplifier starting from the final stage working forward until the defective stage is found.
			Use isolating procedures in para 3–11*c* to locate the defective component.

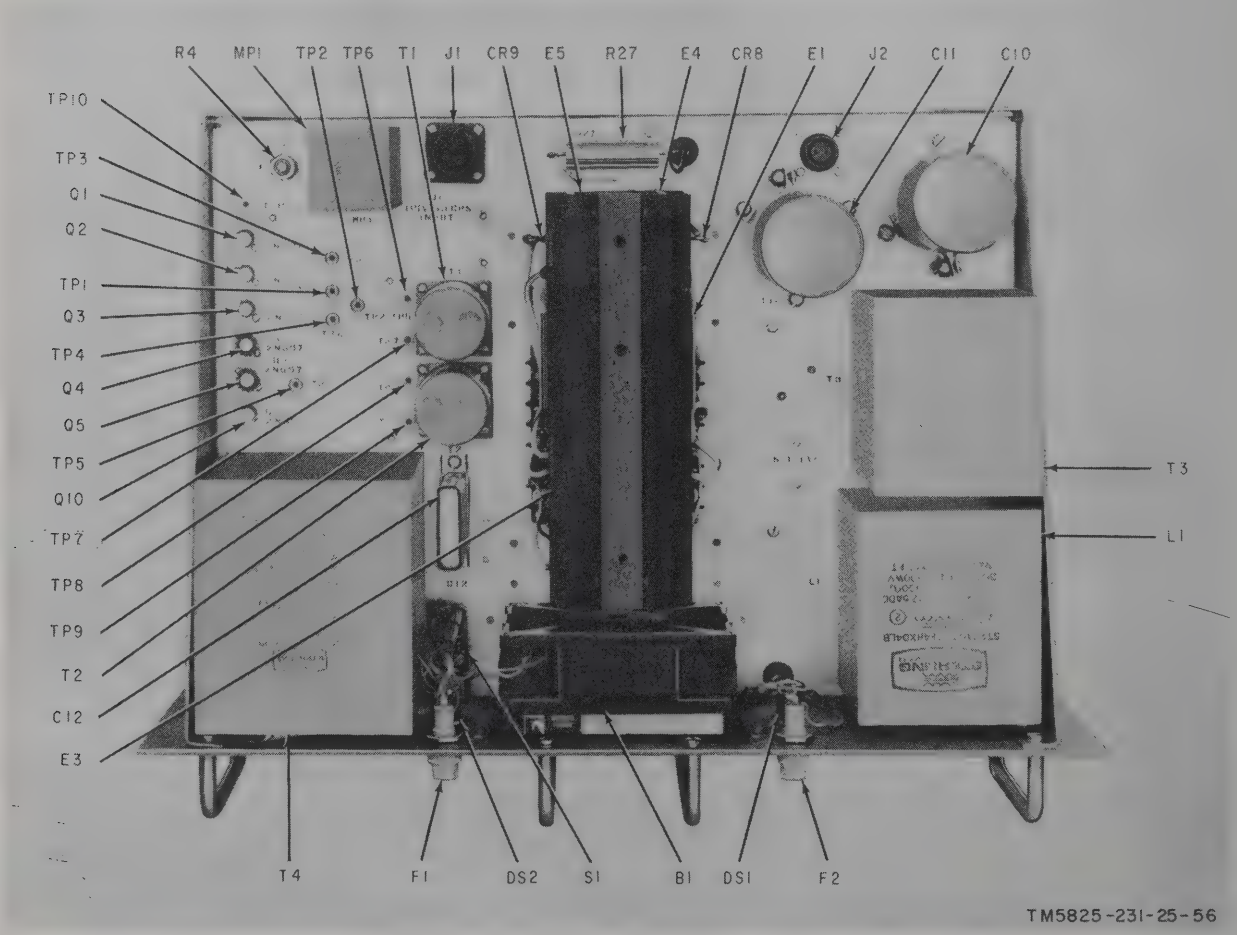

Figure 3–15 (1). Electronic control amplifier, top view, location of parts.

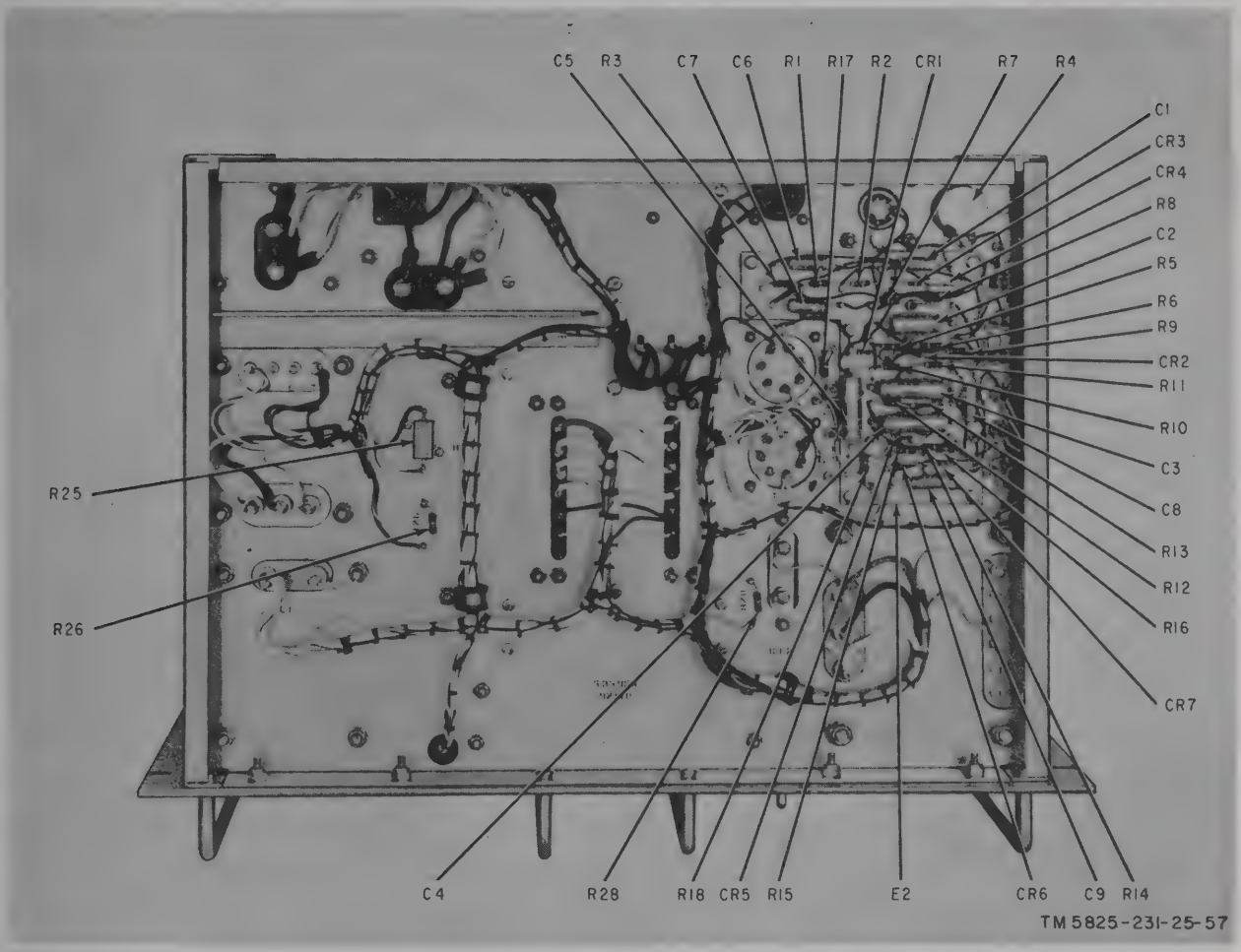

Figure 3–15 (2). Electronic control amplifier, bottom view, location of parts.

e. Isolating Troubles. When trouble has been localized to a stage through preceding operational and intraunit checks, use the following technique to isolate the defective part:

(1) Test the suspected transistor or substitute a similar type.

(2) Take voltage measurements using the voltage chart in *f* below.

(3) Abnormal ac voltages are indicative of loss of stage gain. Open, leaky, or shorted capacitors are the most likely sources of trouble.

(4) Abnormal dc voltages are usually indicative of resistance changes in the stage. Take resistance measurements only where indicated in *f* below and be certain of probe polarity before testing.

(5) Use schematic diagram (fig. 6–20) for tracing signal flow and intercircuit measurements, and photographic presentation for physical location of parts (fig. 3–15).

f. Voltage Measurements, Electronic Control Amplifier.

Note. Two sets of readings are presented in the following chart. One set of voltages is obtained with a 100-watt lamp load. A second set of voltages is given for a no-load condition to verify the performance of the load sensing circuitry.

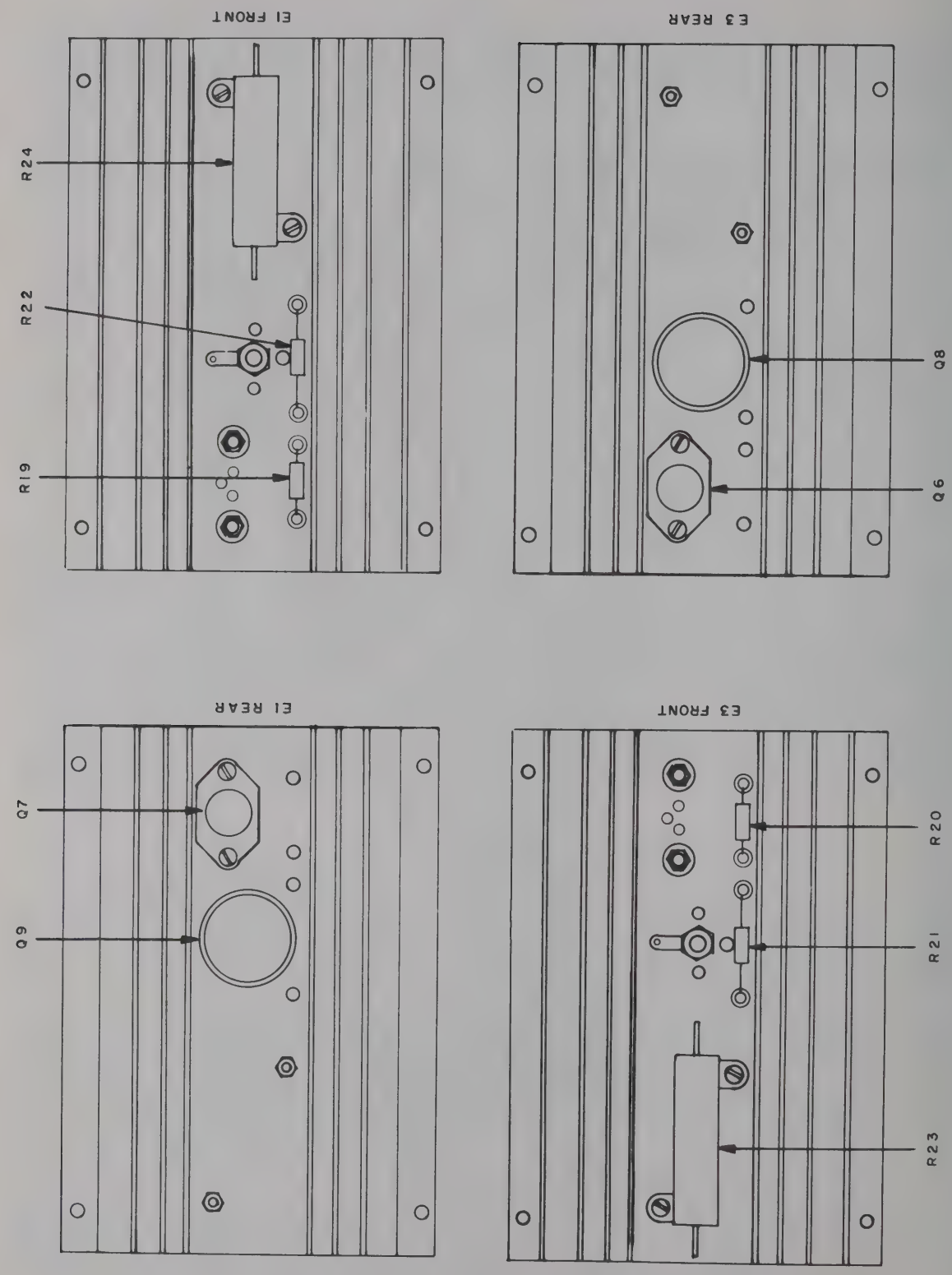

Figure 3-15 (3). Electronic control amplifier, component assemblies E1 and E3.

Amplifier, Electronic Control—DC/AC (Peak-to-Peak) Voltages to Ground

		With 100-w load across J2			With no-load across J2		
		Base	Emitter	Collector	Base	Emitter	Collector
Q1	VDC	5.8	5.4	10.5	6.0	5.4	10.7
	VAC	2.45	2.4	0	2.6	2.6	0
Q2	VDC	0	0	5.75	0.6	0	0.11
	VAC	0.25	0	1.9	0	0	0
Q3	VDC	5.75	4.2	10.5	4.8	4.2	10.7
	VAC	1.25	1.0	0	0	0	0
Q4	VDC	0.44	0	12.0	0.53	0	15.0
	VAC	0.73	0	25.0	0	0	0
Q5	VDC	0.46	0	11.7	0.53	0	15.0
	VAC	0.85	0	25.0	0	0	0.2 *
Q6	VDC	3.05	0	12.1	0	0	15.0
	VAC	14.0	0	2.0	0	0	0.2 *
Q7	VDC	4.1	0	12.1	0	0	15.0
	VAC	13.0	0	1.8	0	0	0.2 *
Q8	VDC	12.1	12.3	2.3	15.0	15.0	0
	VAC	2.0	1.4	24.0	0.2	0.2*	0
Q9	VDC	12.1	12.3	2.2	15.0	15.0	0
	VAC	1.8	1.4	22.0	0.2	0.2*	0
Q10	VDC	11.2	10.5	12.9	11.4	10.7	15.4
	VAC	0	0	0.5	0	0	0.25
MP1-9	VDC		----	----	2.6		
	VAC	2.45					
Across C7	VDC	1.35	----	----	4.6		
	VAC						
Across C8	VDC	2.65	----	----	0.16		
	VAC						
Across R27	VDC	12.7	----	----	15.0		
	VAC	0.4*			0.2 *		

*Ripple.

3–12. Oscilliscope Model 120B

a. General. Functional troubleshooting of the oscilloscope is accomplished to determine in which functional section a malfunction exists. Prior to troubleshooting any functional section, a visual inspection should be performed. Check for open fuse, broken wires, discolored parts, leaky capacitors, etc. The best method for checking tubes is by substitution. Test equipment required is listed in *b* below. No listing of voltages is provided since voltages are shown completely on schematics at proper locations. For location of components, refer to figures 3–16, 3–17, 3–18, and 3–19.

b. Test Equipment Required.

Instrument	Mfr. code No.	Type or model No.
VTVM	49675	400D
Scope	49675	WV77B
VTVM	80009	531/541

c. Bench Testing. Bench testing of the oscilloscope is accomplished by centering position controls setting HORIZONTAL DISPLAY switch to external horizontal input and no signal applied.

d. Trouble Effect. Most troubles occurring in the model 120B will directly affect the display on the CRT; consequently, the troubleshooting procedures are based on the most common types of faults detectable by CRT observations. The chart in *e* below lists the common types of defects that occur in oscilloscope displays, together with the circuits most likely to be at fault, and remedial action required.

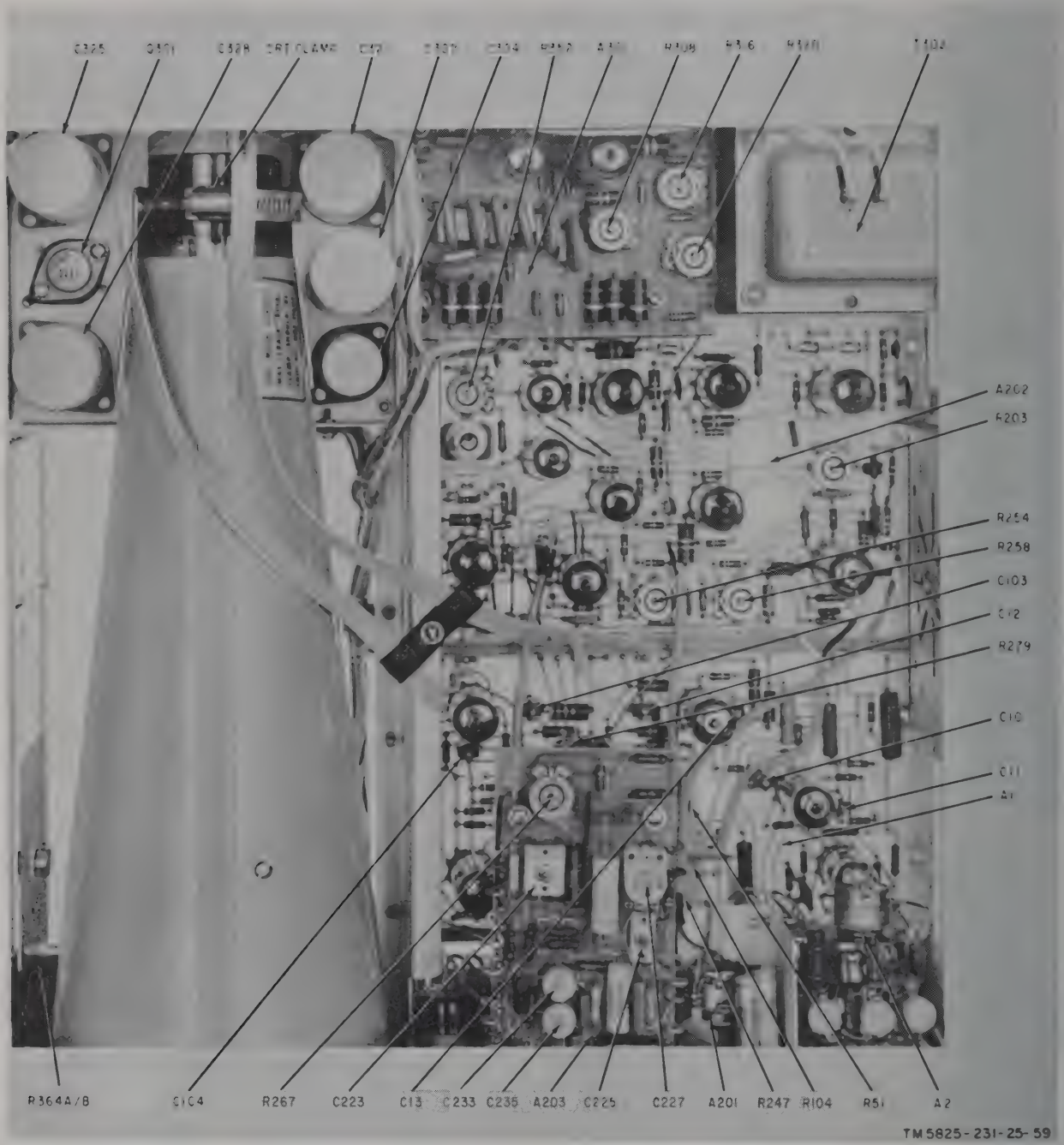

Figure 3–16. Oscilloscope, top view.

e. Troubleshooting Chart.

Item	Trouble	Probable cause	Remedy
1	Nothing visible on CRT with BEAM FINDER depressed.	Low voltage power supply.	Check voltages and resistance in accordance with para 3–12*f*. If out of tolerance, see chapter 4 for adjustment procedures. If adjustment does not correct malfunction, substitute tubes and check remaining components in circuit until faulty component discovered.
		Horizontal or vertical amplifier.	Check plate voltages. Be sure position controls are centered, no signals applied, and HORIZONTAL DISPLAY switch set to external horizontal input. When discovering incorrect plate voltage, make detailed voltage check in that stage, referring to schematic, figures 6–23 and 6–21. Replace faulty component.
		Horizontal or vertical amplifier frequency response.	Check tubes by substitution, then trimmer, bypass and neutralizing capacitors and replace faulty part.
		High voltage power supply or faulty CRT. ***Warning*: Use caution when measuring high voltage. Use proper equipment for high voltage measurements.**	Measure voltage to CRT, and replace CRT if they are normal. Refer to high voltage power supply schematic figure 6–25. If high voltages are not present, check that oscillator V302 is oscillating. Note that faulty CRT cathode supply affects grid supply, but CRT grid supply has no effect on cathode supply. If both are excessively low or high, make voltage checks on V301 and determine faulty component.
2	Vertical sensitivity out of tolerance on all sensitivity ranges but horzional sweep normal.	Vertical amplifier ----------	Check V4, V5, C14, R52 and R55 and replace if defective. See figure 6–23.
3	Vertical sensitivity out of tolerance on one range.	VERTICAL SENSITIVITY switch S2 defective.	Check and replace S2 if defective. If not, check connections.
4	External horizontal sensitivity out of tolerance, but vertical sensitivity normal	Horizontal amplifier ----------	Check components of V101 and V102 and replace defective parts. To check tubes substitute with known good tubes. See figure 6–21.
5	Faulty sweep; external horizontal deflection normal.	Sweep generator----------	A failure in any stage of the sweep generator will indicate abnormal wave forms in all stages, since the sweep generator circuits form a feedback loop. Thus, check of voltages of each stage must be made to find the failure.

Item	Trouble	Probable cause	Remedy
			Refer to sweep generator schematics, figure 6–22 for proper voltages. A 10% to 15% deviation from given values can be expected, larger deviations indicate a source of trouble.
6	Poor focusing, intensity normal.	CRT or voltage power supply____	Refer to item 4.
7	Poor intensity_____	CRT, high voltage or low voltage power supplies.	Refer to item 1 and item 4.

f. Low Voltage Power Supply Voltages.

Voltage**	Tolerance*	Typical** Ripple	Typical** Resistance
–150 volts dc	VTVM Accuracy (±3%)	5 mv	10K
+ 19 volts dc	–1.5 volts; +1 volt	45 mv	4K (with V101 removed)
+300 volts dc	±9 volts	45 mv	75K
+100 volts dc	±3 volts	15 mv	50K
+ 99volts dc	±3 volts	15 mv	

* Line voltage 115 or 230 volts ac, as required.
** With respect to chassis ground.

3–13. Power Distribution Panel

a. General. Extreme caution should be exercised in preparation for troubleshooting this panel because of the high-power available. Before making any checks, disconnect input 115 or 230 volt line. After disconnecting J1 or J2, (fig. 6–6 and 3–20) as applicable, make a complete visual check to insure that all connections are tight and proper, and switches S1, S2 are off.

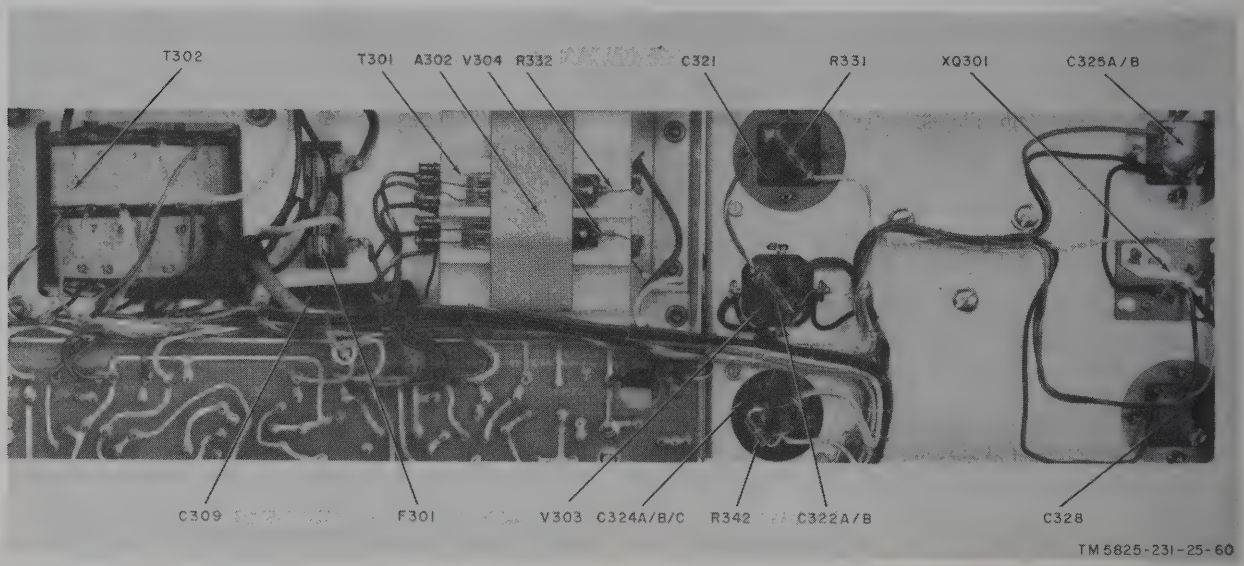

Figure 3–17. Oscilloscope, HV power supply.

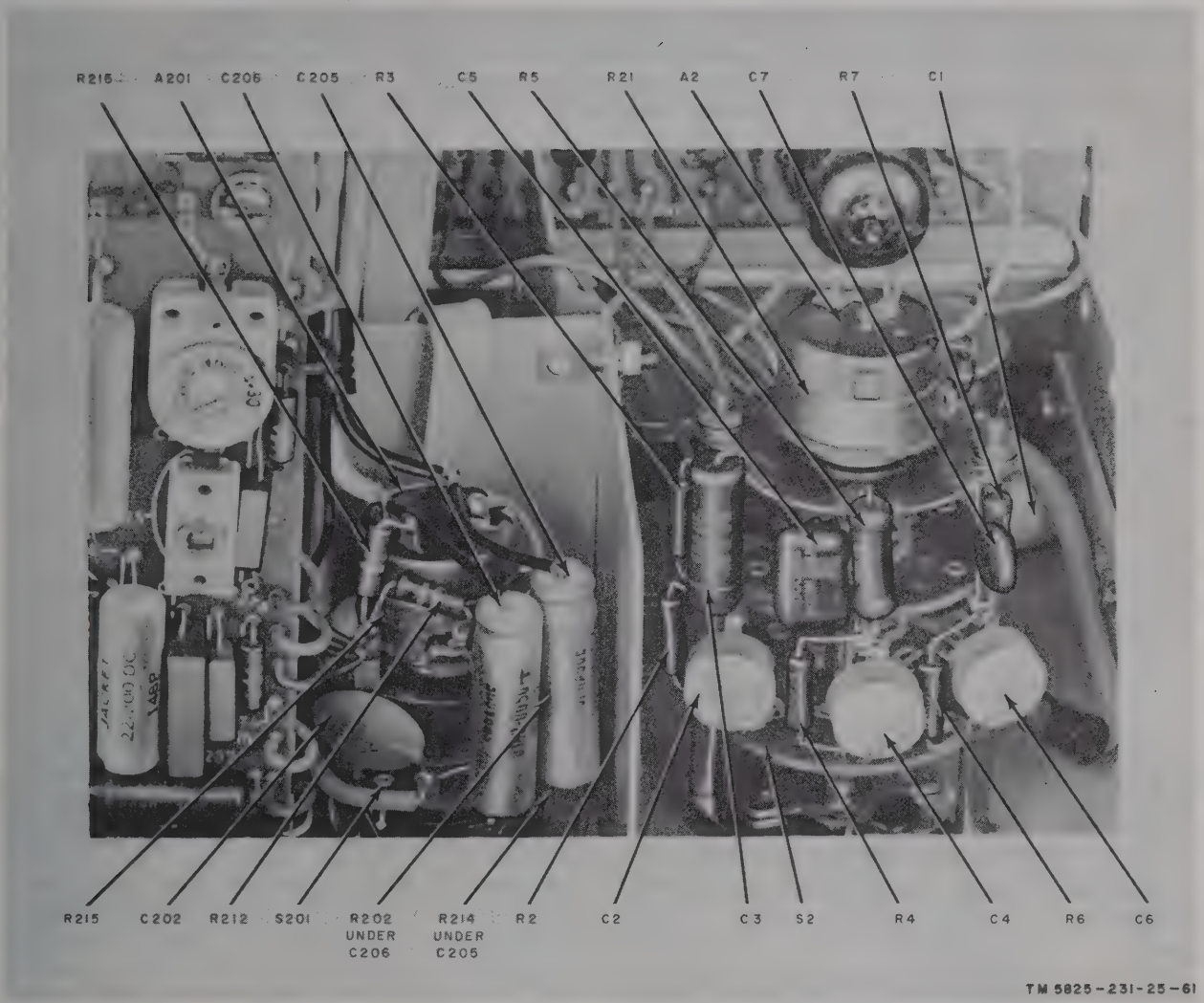

Figure 3–18. Oscilloscope vertical sensitivity and trigger level switches, parts location and adjustment.

b. Test Equipment. The only test equipment necessary to complete troubleshooting is a 260 VOM. Probable troubles, causes and remedy necessary to correct the malfunctions are listed in *d* below.

c. Frayed or Open Wires. Before applying power, check that no frayed or open wires are touching each other or the cover. Push in circuit breakers CB1 and CB2, and make sure J2 is plugged into the 115 VAC line or J1 into the 230 line. If circuit breaker opens, reset once. If it opens again, do not reset until cause of overload is corrected.

Note. Never hold in circuit breaker as this defeats its purpose and could seriously damaged equipment.

d. Troubleshooting Chart—Power Distribution Panel.

Item	Trouble	Probable cause	Remedy
1	Meters M1 and M2 do not indicate voltage and frequency of power source.	Circuit breaker CB1 or CB2 open	Press Cb1 or CB2, depending on whether using 115 V or 230 V.

Item	Trouble	Probable cause	Remedy
		Defective switch contacts in switch S1 or S2.	Replace switch.
		Defective meters, short circuit across output load.	Replace defective meters. Locate short and repair.
		Transformer T1 is open	Replace transformer.
2	Normal meter readings are obtained with 115v ac power input to receptacle J2, but no voltage is indicated when a 230v ac power is connected to receptacle J1 (switch set at 230v position).	Circuit breaker CB1 is open	Press reset button CB1.
		Defective switch contacts S1	Replace switch.
		Open transformer T1	Replace transformer T1.
3	Normal meter readings are obtained with a 230v ac power input to receptacle J1, but no voltage is indicated when a 115v ac power input is connected to receptacle J2 (switch set at 115v position).	Circuit breaker CB2 is open	Press reset button CB2.
		Defective switch contacts S2	Replace switch.
		Open transformer T1	Replace transformer T1.
4	Voltmeter fluctuates	Fluctuating input from source.	Test input line back to souurce.
		Defective input plugs J1, J2	Replace plugs.
		Defective output receptical J3, J4, J5.	Replace receptacles.

3–14. Target Transmitter T-279A/UR

a. General. Before applying power, check visually to ascertain that no wiring is frayed or open. Check B+ and filament voltages if prior information indicates possible short circuit exists.

b. Test equipment required for troubleshooting this transmitter is a TV–7A or TV–7B tube tester, 260 (or equivalent) volt-ohmmeter and a radio receiver operating at the target transmitter frequency.

c. The troubleshooting chart (*e* below), lists troubles, probable causes, and corrective action necessary for repair of the equipment.

d. The location of components is shown in figures 3–21 and 3–22. The voltage/resistance measurements are shown in figure 6–8 and *f* below.

e. Troubleshooting Chart.

Note. A receiver will be required to check for the output signal.

Item	Trouble	Probable cause	Remedy
1	Flashing indicator lamp does not light.	Dead batteries	Check batteries, and replace if below standard.
		Dirty lamp socket contacts	Inspect contacts and clean.
		High humidity	None—disregard if transmitter functions otherwise.
2	No output signal on all bands.	Dead batteries	Check batteries, and replace if below standard.
		Defective oscilator or amplifier tube (3A5 or 3A4).	Replace tube.
		Defective BAND SWITCH (S603).	Repair or change BAND SWITCH.
		TUNING CAPACITOR (C601 or C602) shorted by foreign matter or bent plates.	Repair or replace capacitor. Realine after this operation.

Item	Trouble	Probable cause	Remedy
3	No output signal on one band.	Defective BAND SWITCH contact.	Repair or replace switch.
		Defective coil	Test coil of dead band. Repair or replace and realine.
4	No MCW signal	Defective tube (1R5)	Replace tube.
		Defective switch (S602)	Replace switch.
5	Intermittent operation	Poor connections	Inspect and repair.
		Noisy tube	Check tubes, replace if necessary.
		Defective contacts in BAND SWITCH (S603).	Inspect contacts, clean or repair switch.
6	Weak output signal or increase output control inoperative.	Weak batteries	Check batteries and replace if below standard.
		Defective amplifier tube (3A4).	Replace tube.
		Defective potentiometer (R609).	Check resistance at maximum and minimum positions.
7	Frequency calibration incorrect or varies.	Dirty BAND SWITCH (S603) contacts.	Clean BAND SWITCH contacts.
		Dial drive machanism or shaft coupling set screws loose.	Tighten set screws.
		Incorrect adjustment or alinement of coils.	Realine coils.

f. DC Resistance of Transformers and Coils. The dc resistance of the transformer windings and the coils in the target transmitter are as follows:

Transformer or coil	Terminal	Ohms
L601	Across ends of coil	5.0
L602	Across ends of coil	2.2
L603	Across ends of coil	.8
L604	Across ends of coil	Less than 1 ohm
L605	Across ends of coil	Less than 1 ohm
L606	Across ends of coil	Less than 1 ohm
L607	Across ends of coil	7.8
L608	Across ends of coil	2.8
L609	Across ends of coil	.8
L610	Across ends of coil	Less than 1 ohm
L611	Across ends of coil	Less than 1 ohm
L612	Across ends of coil	Less than 1 ohm
L613	Across ends of coil	25

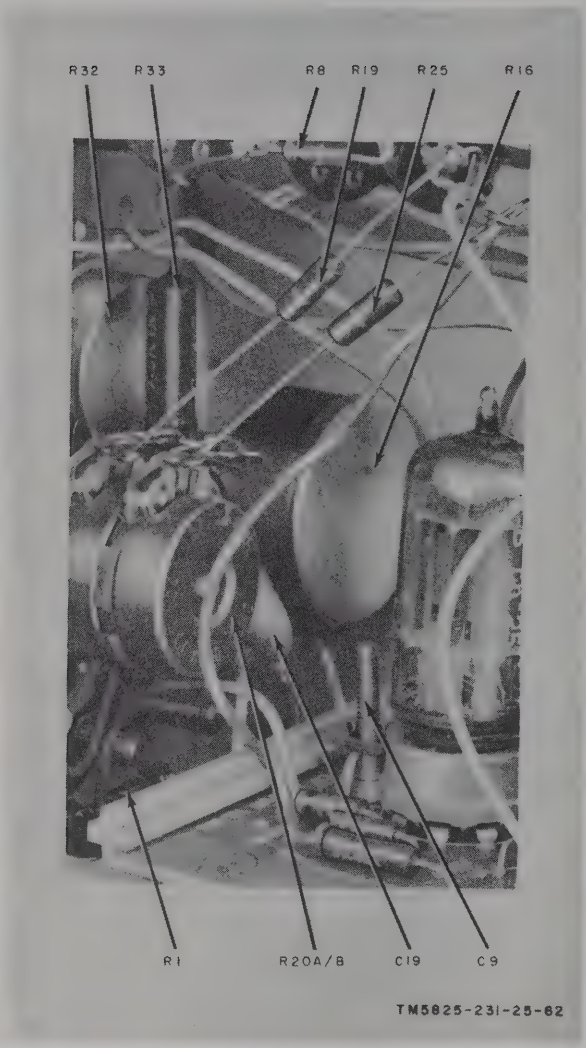

Figure 3–19. Oscilloscope, right side view, side panel removed.

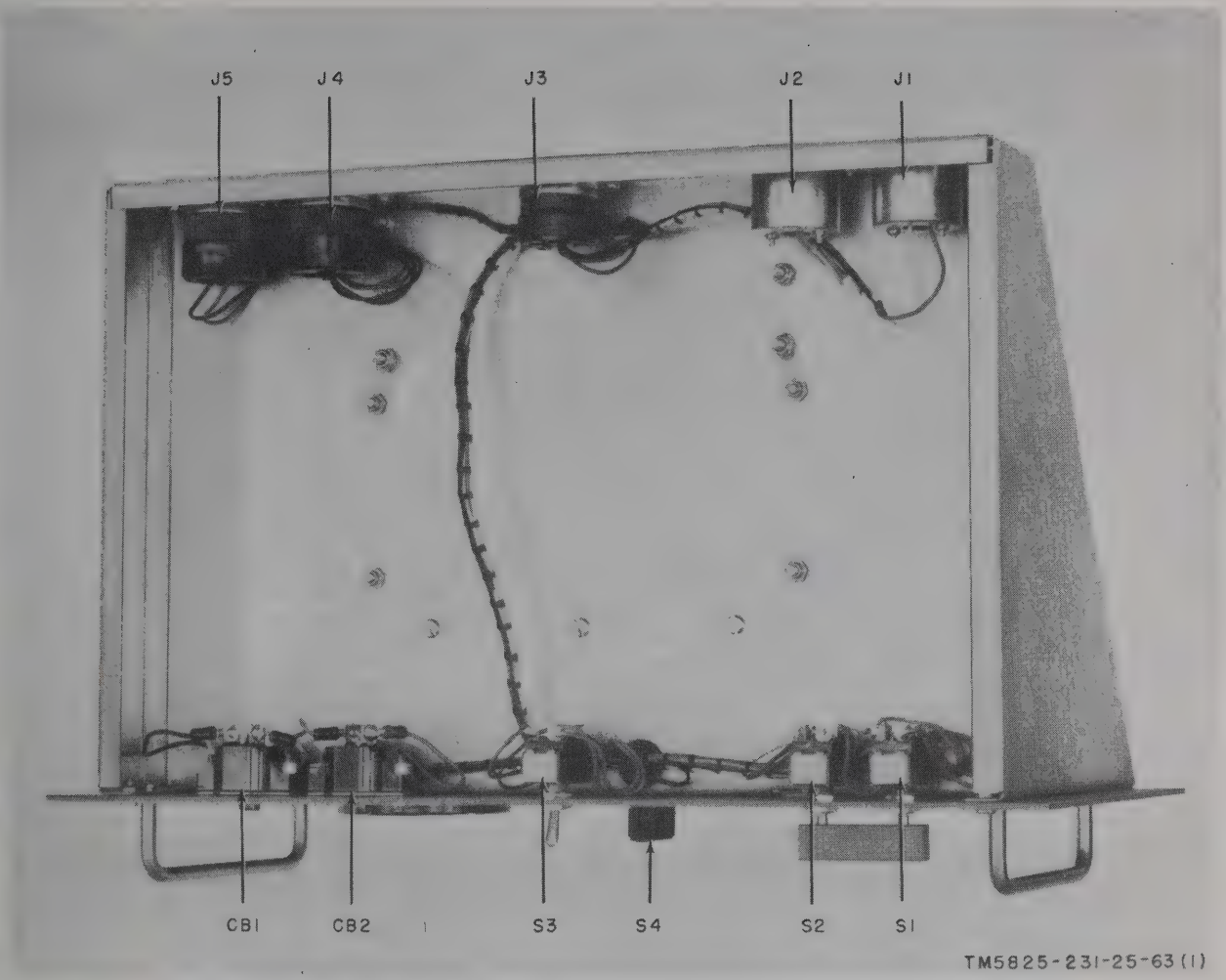

Figure 3-20 (1). Power distribution panel, location of parts.

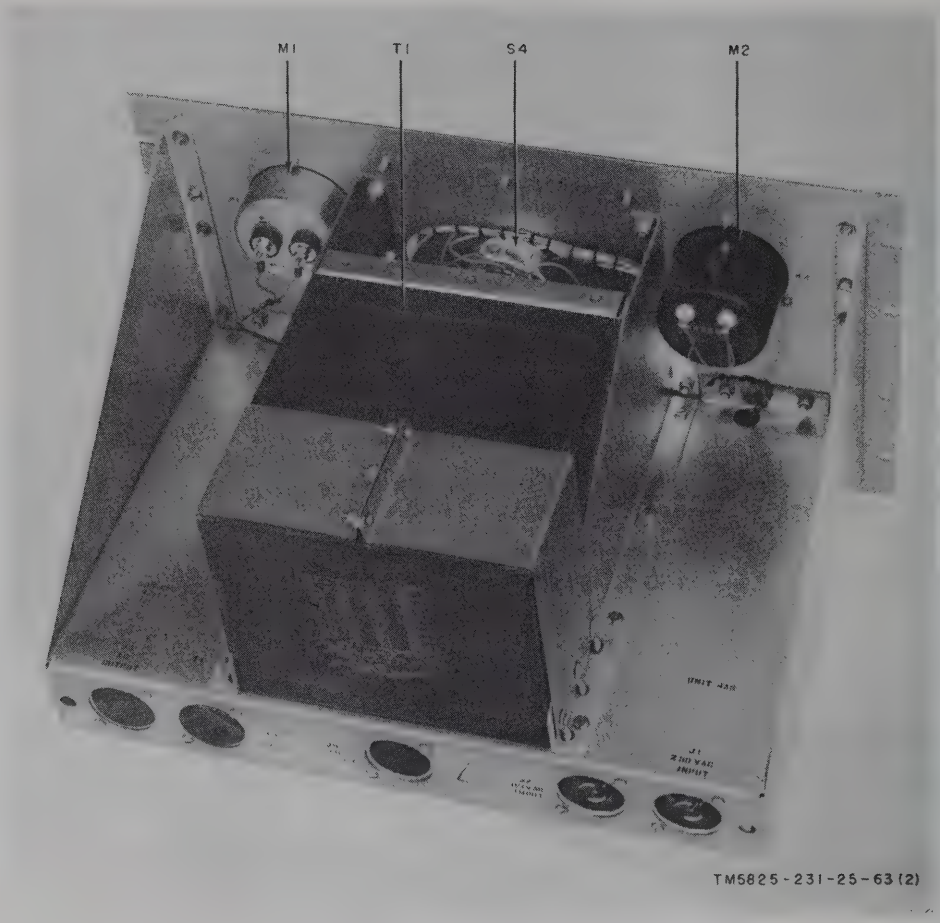

Figure 3–20 (2). Power distribution panel, location of parts.

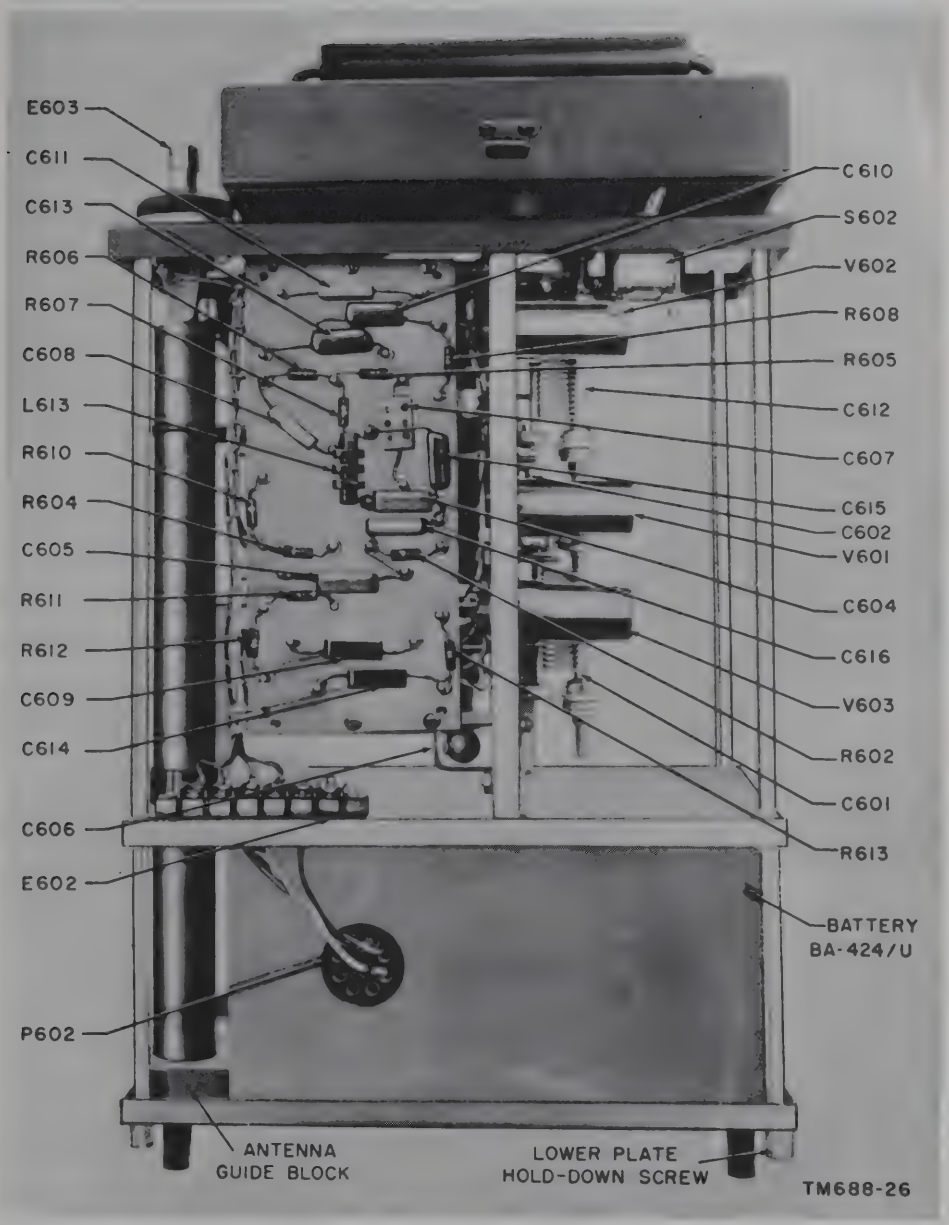

Figure 3-21. Radio transmitter T-279A/UR, view of front, case removed.

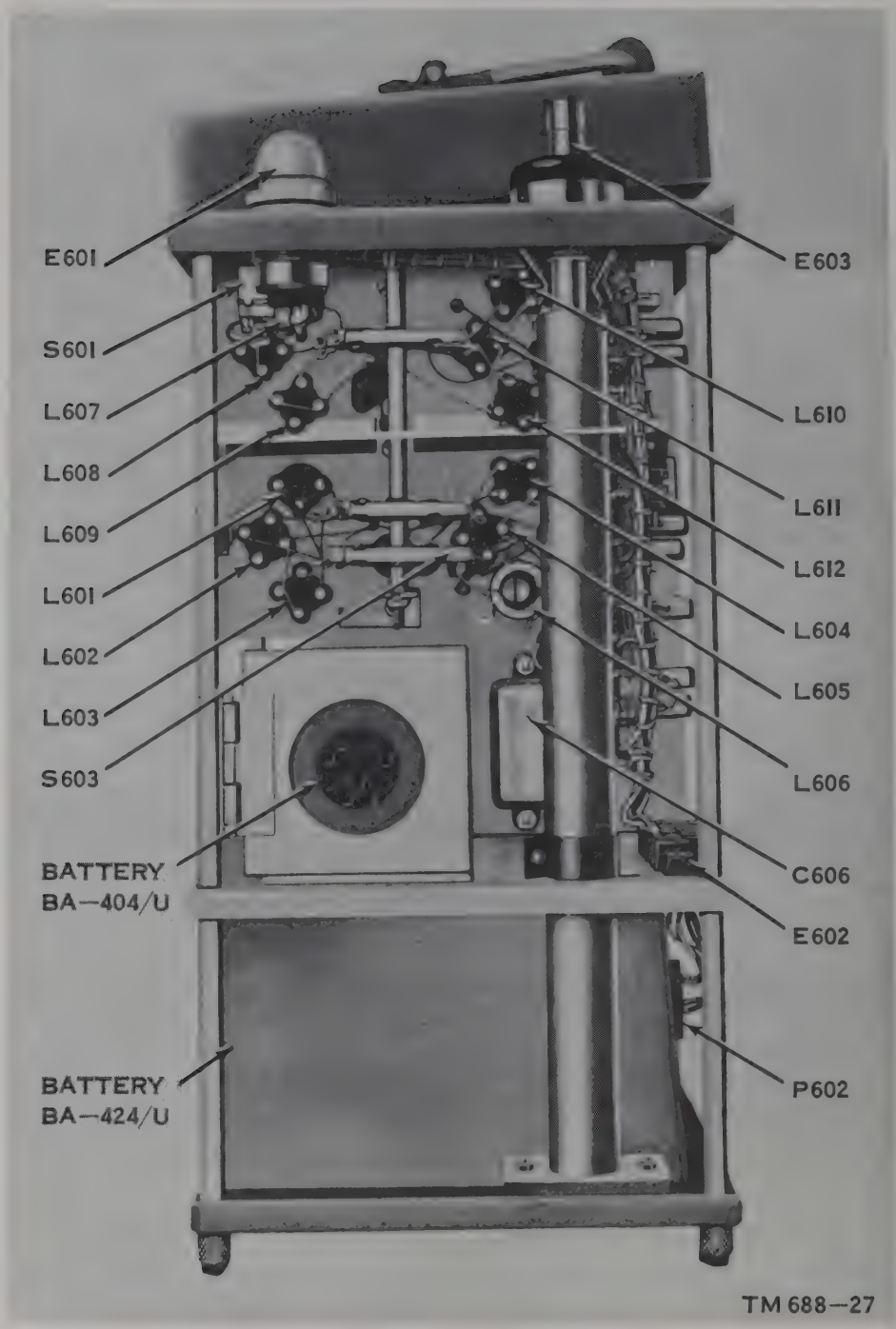

Figure 3-22. Radio transmitter T-279A/UR, view of left side, case removed.

CHAPTER 4

REPAIRS AND ALIGNMENT

Section I. REPAIRS

4–1. General

a. For performing repairs to Radio Receiver R–725/URR, refer to TM 11–5820–358–35 (Radio Receiver R–390A/URR) chapter 2, section III.

b. Paragraph 64*b* of TM 11–5820–358–35 is not applicable to the repair procedures for the R–725/URR

4–2. Parts Replacement Techniques

a. General. Most of the parts in the units of the Radio Direction Finder Set AN/TRD–15 can be reached easily and replaced without special procedures. The following precautions and special handling instructions apply to the units specified.

b. Electronic Control Amplifier Chassis.

(1) When it becomes necessary to remove a part in this transistorized unit, use a pencil-type soldering iron with a 25-watt maximum capacity.

(2) Isolate an ac operated soldering iron from the line by a suitable isolation transformer to prevent current leakage from damaging the part

(3) Do not use a soldering gun. Damaging voltages can be induced in components.

(4) The use of heat sinks on the leads of transistors, diodes, and tantalytic capacitors is necessary to prevent component damage from soldering heat. A long-nose plier will serve as an efficient heat sink when the component lead is firmly grasped.

c. Azimuth Indicator Unit.

(1) Special handling of the CRT is required when removal and replacement is necessary. Follow the procedures in (2) and (3) below carefully to avoid serious personal injury.

Caution: **This is a critical operation and must be done exactly as described. CRT glass envelope is under negative pressure and could implode if cracked.**

(2) Removal of CRT.

(*a*) Remove three screws and hairline rotor knob from side of rim of alidade assembly and remove rim.

(*b*) DO NOT touch four spring-loaded, slotted head screws extending out from alidade assembly face.

(*c*) Insert 9/64 inch Allen head screwdriver in each of four recessed screws in face of alidade assembly and loosen each a little at a time until assembly comes off.

(*d*) Loosen clamp screws on neck of tube and socket clamp at rear of CRT.

(*e*) Pull socket from CRT base carefully.

(f) Push CRT forward from rear. Heavy pressure must be exerted to push far enough out from rubber padding in steel housing to be able to grasp the front of the CRT.

(*g*) When tube is far enough out in front to grasp, pull out carefully the rest of the way. Caution should be taken that tube does not flip out suddenly.

(3) Replacement of CRT.

(*a*) Guide replacement tube carefully into housing so number 5 socket pin is top dead center. Connect socket.

(*b*) Place alidade assembly over front of tube and hold tightly against chassis in normal position.

(*c*) With other hand, rotate crosshair to make sure there is no binding or contact of alidade window with tube face.

(*d*) Be sure tube is not recessed too far. If so, move forward to proper position, and retest for binding or chaffing.

(*e*) With CRT in proper position, tighten the four Allen head screws, adjusting each a few turns at a time, going from one to the next in clockwise order.

(*f*) Replace three rim screws and crosshair rotor knob on alidade rim.

(*g*) Retest crosshair window rotation to make sure it is not binding at this point. If it is, loosen alidade assembly and push CRT into housing 1/16 inch. Replace housing and retest window; it should not bind.

(*h*) Tighten tube clamp and connector clamp screws until tube and connector are firmly seated. (Be certain that tube socket pin 5 is top dead center before tightening).

d. Monitor Oscilloscope.

(1) *Replacement of semiconductors.*

(*a*) Excessive heat can destroy semiconductors. When soldering or unsoldering transistors or diodes, place a heat sink (such as long nose pliers) on the lead part.

(*b*) Isolate the oscilloscope from ground, or ground the body of the soldering iron to prevent leakage currrent from damaging the part.

(*c*) When replacing Q301, use a thin coat of silicone grease on each side of the insulator to improve heat transfer from transistor to deck.

(2) *Servicing etched circuit boards.*

(*a*) Removal of components, such as tube sockets, that are attached to the board at more than two points is difficult when trying to remove the part intact. Simplify the removal by first cutting the pins or other connections between the body of the part and the circuit board, and then remove the pins individually.

(*b*) Excessive heat or pressure can lift the copper strip from the board. Avoid damage by using a low-power soldering iron (50 watts maximum) and following these instructions. Copper that lifts off the board should be cemented in place with a quick drying acetate base cement having good electrical insulating properties.

(*c*) A break in the copper should be repaired by soldering a short length of tinned copper wire across the break.

(*d*) Use only high quality rosin core solder when repairing etched circuit boards. NEVER USE PASTE FLUX. After soldering, clean off any excess flux and coat the repaired area with a high quality electrical varnish or lacquer.

(*e*) When replacing components with multiple mounting pins such as tube sockets, electrolytic capacitors, and potentiometers, it will be necessary to lift each pin slightly, working around the components several times until it is free.

(3) *CRT replacement.*

Warning: **When replacing the CRT, handle CRT with care; wear gloves and plastic face mask or goggles.**

(*a*) Remove four mounting screws from bezel, and remove bezel.

(*b*) Loosen clamp screw (fig. 3–16) on CRT base; do not remove screw or clamp.

(*c*) Remove socket from CRT base.
(*d*) Slide CRT forward and out.
(*e*) Replace in reverse order.
(*f*) Energize the oscilloscope and obtain a free running trace.
(*g*) If necessary, align graticule and trace by adjusting SCALE control.

e. Drive, Goniometer – Rotary Coupler.

(1) *Removal of goniometers.* The primary and secondary goniometers are mounted identically so that the removal procedure applies to both.
(*a*) Loosen the two Allen head setscrews on the flexible goniometer drive coupling which secure the coupling to the goniometer shaft. A hole in the top of the drive housing (fig. 3–13) provides access to the coupling setscrews.
(*b*) Remove the two hex-head bolts (fig. 3–13) which secure the goniometer mounting plate to the drive housing.
(*c*) Pull the goniometer forward slowly noting that the shaft is released from the coupling and not flexing it unduly.

(2) *Replacement of goniometers.* The primary and secondary goniometers are replaced identically as follows;
(*a*) Align goniometer shaft with coupling in the drive housing. Do not force alignment since the flexible coupling may be damaged.
(*b*) Engage the goniometer assembly with the coupling in the drive housing until the mounting plate is flush with the housing and boltholes are aligned with slotted holes in mounting plate.
(*c*) Insert and tighten the two hex-head mounting bolts.
(*d*) Tighten the two Allen head setscrews on the shaft coupling accessible through the top hole in the drive housing.

f. Radio Transmitter T–279A/UR.

(1) Most of the parts in Radio Transmitter T–279A/UR are readily accessible and are easily replaced if found to be faulty. The following items require the attention described below when replacements are necessary.
(*a*) If the band switch S603 (fig. 3–22) requires replacement, mark the wires connected to the switch carefully with tags or other identification to avoid misconnection when a new switch is installed.
(*b*) To replace any one of the twelve RF coils, first unsolder the leads from the top of the coil. Then unscrew the nut holding the coil to the vertical chassis, and lift out the coil.

(2) Follow the practice of marking leads which must be disconnected to permit replacement of items having multiple connections as in (*a*) above.

Section II. ALIGNMENT

4–3. Test Equipment Required

a. Test equipment requirements for the Radio Receiver R–725/URR are adequately covered in TM 11–5820–358–35 except for the IF subchassis which are contained herein.

b. The following test equipment is required for alignment of those units of the system as described in paragraphs 4–4*a* through *i*.

Item	Mfr. code No.	Type or model No.
AC liner meter	16902	49
AC voltmeter (VTVM)	28480	400D
Amplifier, electronic control.	92110	AM–3545/TRD
Audio oscillator	28480	200CD
Electronic counter	28480	544D

Item	Mfr. code No.	Type or model No.
Multimeter (VOM)	16902	260/269
Oscilloscope	80009	531/541
Phrase shift network	Signal Corps to fabricate.	Figure 3–6
Radio receiver	92110	R–725/URR
Signal generator, AM/FM	07980	202E
Signal generator, RF	28480	400D
Square wave generator	28480	211A
Test circuit (B+)	Signal Corps to fabricate.	Figure 3–10
Test circuit (filament)	Signal Crops to fabricate.	Figure 3–9
Test fixture	92110	SCA535748–17
Time marker generator	80009	211A
Univerter	07980	207E
Vacuum tube voltmeter (with high voltage probe).	03606	WV77B
Variable transformer	58474	116

4–4. Procedures

a. Alignment of the Azimuth Indicator.

(1) The alignment procedure described herein will insure that the indicator is properly adjusted and functioning for satisfactory operation in the Direction Finder Set AN/TRD–15.

(2) Test equipment required.

Item	Mfr. code No.	Type or model No.
AC line meter	16902	49
Amplifier, electronic controlled.	92110	AM–3545/TRD
Audio oscillator	28480	200CD
Multimeter (VOM)	16902	260
Oscilloscope	80009	531
Test fixture	92110	SCA535748–17
Vacuum tube voltemeter (with high voltage probe).	03606	WV77B
Variable transformer	58474	116

(3) The setup for the alignment procedure is shown in figure 3–2.

(4) The setting of the controls prior to alignment is listed below.

Control	Symbol	Setting
Main power switch	S1	off
Intensity	R60	Fully CCW
Focus	R57	Center of rotation
H centering	R48	Center of rotation
V centering	R49	Center of rotation
Dimmer	R74	Fully CCW
DF gain	R1	Fully CCW
Size	R33	Fully CCW
Shape	R17	Center of rotation

Control	Symbol	Setting
RCVR mode switch	S2	1-RCVR
MON-DF mode switch	S3	DF

(5) Adjustments for aligning low voltage supply.

(*a*) Connect VOM, set to 1000 vdc scale, (+) lead to V6-1 (-) lead to chassis.

(*b*) Adjust B+ ADJUST control R72 for a +275 volt reading on the meter.

(*c*) Connect oscilloscope in parallel with VOM.

(*d*) Adjust HUM BALANCE control R67 for minimum ac ripple as displayed on oscilloscope.

(6) Check of high voltage supply.

(*a*) There are no adjustments to be made to the high voltage supply.

(*b*) Connect the VTVM, set to -6 kc scale with high voltage probe attached, to the junction of CR9 and C34, and the chassis.

(*c*) Measure between -4000 and -4400 vdc. If voltage is out of tolerance, refer to the troubleshooting section (para 3-6*d*).

(7) Check of intensity, focus, and centering.

(*a*) Turn up INTENSITY control to obtain a spot on the face of the CRT.

(*b*) Adjust FOCUS control to insure adequate control of focusing either side of optimum.

(*c*) Leave spot defocused to avoid burning CRT.

(*d*) Adjust H and V centering controls to assure proper control over positioning the dot sufficiently from the center. A travel of at least $\pm 1/4$ inch from the center in either horizontal or vertical is required.

(*e*) There are no alignment adjustments for intensity, focus or centering. Refer to the troubleshooting section if the presentation required above is not attained.

(8) Oscillator Alignment.

(*a*) Connect oscilloscope probe to V6-3 and ground clip to chassis.

(*b*) Adjust L1 for a maximum peak-to-peak signal on the oscilloscope.

(*c*) The signal level should be between 24 and 36 volts peak-to-peak.

(9) Pattern alignment.

(*a*) Apply power to the electronic control amplifier to drive the test fixture at 5400 rpm.

(*b*) Increase SIZE control to obtain an appropriate 3/4 deflection circular pattern on the CRT. Adjust INTENSITY, FOCUS, and SHAPE controls as necessary. While observing CRT pattern, adjust T2 (modulator tuning) for a maximum deflection.

(*c*) Readjust SIZE control as necessary to maintain an approximate 3/4 deflection. Adjust T3 (amplifier tuning) for maximum deflection. Adjust T4 (horizontal output) for maximum horizontal deflection and T5 (vertical output) for maximum vertical deflection. Adjust SIZE and Shape controls as necessary to obtain a full deflection circular pattern. A slight readjustment of T4 or T5 is required to minimize center star.

(*d*) Carefully check edges of pattern for circumferential split. A slight readjustment of L1 and/or T3 may be necessary to minimize split. The final pattern should be sharply focused, face of distortion, flattening

or circular splits, and produce a center star less than 1/16 inch across the flats.

(10) Propeller alignment.

(*a*) With equipment connected and adjusted as in the preceding paragraph, connect the audio oscillator, set for 90 cps, to J1 of the indicator.

(*b*) Remove tube V7 to disable blanking circuitry and increase DF GAIN control to obtain a fully formed propeller.

(*c*) Adjust frequency of audio oscillator to achieve a slowly rotating propeller pattern. While observing rotating pattern, adjust BALANCE control R9 and CUSP BALANCE R77 to obtain an optimum superimposed propeller, with minimal side splits and angular splits throughout the 360° rotation. (R-9 controls side splits while R77 controls angular tip splits.)

(*d*) The resulting propeller pattern should display sharp tips and the face of distortion, defocusing and angular splits to within 1/4°.

(11) Blanking Adjustment.

(*a*) With test setup as in the (10) above, insert V7 into its socket.

(*b*) After 1-minute warmup and with INTENSITY control set at a normal level, adjust T7 (sense tuning) so that one-half of the propeller is totally blanked out. Precise adjustment is required to eliminate any evidence of ghosts or tails.

b. Alignment of the RF Detector.

(1) The alignment procedure described herein will assure that the RF detector is properly adjusted and functioning for satisfactory performance in the Direction Finder Set AN/TRD-15.

(2) Test equipment required.

Equipment	Mfr. code No.	Type or model No.
AC line meter	16902	49
AC voltmeter	28480	400D
Audio oscillator	28480	200CD
Electronic counter	28480	544D
Oscilloscope	80009	541
Phase shift network	92110	Fig. 3-6
Signal generator, AM/FM	07980	202E
Signal generator, RF	28480	606A
Univerter	07980	207E
Variable transformer	58474	116
Volt ohmmeter	16902	269

(3) The setup required for aligning the RF detector is shown in figure 3-5.

(4) The control settings of the test setup prior to alignment are as follows:

Control	Symbol	Setting
Output voltage	R13 of power supply	+250 VDC TP13 to GRD
Hum balance	R2 of power supply	Min. ACV TP13 to GRD

(5) Adjustments for aligning receiver no. 2 limiter chain.

(*a*) Connect electronic counter to TP1 to check for the presence of 455 kc from the oscillator V1.

(*b*) Connect oscilloscope to TP2 and GRD and adjust L5 for a peak scope reading.

(*c*) Move oscilloscope to TP3 and GRD, remove crystal Y2, and adjust L6 for a peak reading.

(*d*) Move oscilloscope to TP4 and GRD, insert crystal Y2, and adjust L7 for a peak 100-kc reading on the scope.

(6) Adjustments for aligning receiver No. 1 limiter chain.

(*a*) Install jumper between TP1 and TP5.

(*b*) With oscilloscope connected to TP6 and GRD, adjust L8 for a peak reading on the scope.

(*c*) With oscilloscope at TP7 and GRD, and crystal Y3 removed, adjust L9 for a peak scope reading.

(*d*) With oscilloscope at TP8 and GRD, and crystal Y3 reinstalled, adjust L10 for a peak 95-kc reading on the scope.

(7) Adjustments for 5-kc output.

(*a*) Connect oscilloscope to TP9 and GRD.

(*b*) Retrim L7 and L10, if needed, to produce a maximum 5-kc signal on the scope.

(8) Harmonic filter alignment.

(*a*) Connect AC VTVM into TP11 and check for minimum hum while retrimming HUM BALANCE control R2 on the power supply chassis.

(*b*) Leave previously connected jumper between TP1 and TP5 in place and proceed with VTVM connected as in (a) above.

(*c*) Connect audio oscillator to TEST SIG. jack J9 and monitor frequency with parallel-connected electronic counter.

(*d*) Tune the oscillator to exactly 360 cps, as verified by the counter, and with the level set for a +10 dbm VTVM reading (90 cps) at TP11, adjust L11 and R100 alternately several times to achieve the best null.

(*e*) Change the oscillator to exactly 270 cps and adjust L12 and R102 alternately a sufficient number of times until the best null is achieved.

(*f*) Shift the oscillator to exactly 180 cps and adjust L13 and R104 as above for best null.

(9) Alignment of auxiliary output (AUX. OUTPUT–J7).

(a) Remove VTVM from TP11.

(*b*) Connect oscilloscope to TP12 and GRD.

(*c*) Reset oscillator, connected as above to TEST SIG. jack J9, to 90 cps as verified by the paralled-connected counter.

(*d*) Adjust AUX. BALANCE control for a balanced negative going, full wave rectified output as viewed on the scope.

c. Adjustment of Power Supply, RF Detector.

(1) The procedure for adjustment of the power supply has been discussed previously where the supply was used as a power source during alignment of the RF detector unit. However, when the RF detector unit is not available as a normal load for the power supply, the following procedure must be performed.

(2) Test equipment required.

Equipment	Mfr. code No.	Type or model No.
AC line meter	16902	49
Oscilloscope	80009	541
Test circuits (2)	Signal Corps to fabricate	Figures 3–9 and 3–10
Variable transformer	58474	116
Volt ohmmeter	16902	269

(3) The setup required for adjusting the power supply, RF detector is shown in figure 3–5 except that the RF detector unit is removed as a load from J2 and the test circuits of figures 3–9 and 3–10 are applied instead as a substitute load. Turn on the power supply unit.

(4) With VOM set to the 10 VAC scale, measure approximately 6.3 VA across J2A and J2B. There is no adjustment for this voltage, but the load attached is a necessary part of this procedure.

(5) With the VOM set to the 1000-VDC scale, measure the voltage across J2D (+) and J2C (–) for both load conditions. Adjust OUTPUT VOLTAGE control R14 until the meter reads +250 VDC.

(6) With the oscilloscope across J2D and J2C, adjust HUM BALANCE control R2 for a minimum peak-to-peak ac voltage. If the dc voltage changes with an adjustment of R2, repeat steps (5) and this step.

d. Alignment of the IF Subchassis.

(1) The procedure which follows is used instead of that section of TM 11–5820–358–35 which deals with the alignment of the IF subchassis.

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(2) Test equipment required.

Equipment	Mfr. code No.	Type or model No.
AC line meter	16902	49
DC voltmeter	03606	WV77B
Signal generator	28480	606A
Variable transformer	58474	116

(3) Connect the Radio Receiver R–725/URR in a test configuration similar to that described in TM 11–5820–358–35 except for the substitution of equivalent types of test equipment in the above chart. Use a variable transformer to maintain the supply at 115 vac.

(4) Before performing the alignments, allow the receiver to warm up for 1 hour minimum.

(5) Alignment procedure (figure 4–1).

(*a*) Turn ON the signal generator, 606A or equivalent, and connect the output to test point E211 (control grid of the third mixer tube V204).

(*b*) For an output meter, connect the grounded lead of a VTVM, such as the DC Voltmeter WV77B to the Receiver chassis, and connect the other lead to the DIODE LOAD terminal 14 of the rear terminal strip. Set the function switch of the VTVM for measuring negative dc voltage.

(*c*) Set the BANDWIDTH switch to the .1-kc position, RF GAIN control to 10, BFO switch to OFF, and FUNCTION switch to MGC. Allow the receiver to warm up as in (4) above.

(*d*) Tune the signal generator to 455 kc (unmodulated); then adjust its frequency control for peak reading on the VTVM. To obtain peak reading, it may be necessary to set the attenuation of the signal generator for high amplitude output signal (3 volts). If a reading on the VTVM is obtained, proceed to (*e*) below. If no reading is obtained, perform the procedure outlined in *1* and, if necessary, *2* below, to secure approximate alignment before proceeding to (*e*) below.

1. With the signal generator tuned to 455 kc and the attenuator set for full output, turn the re-

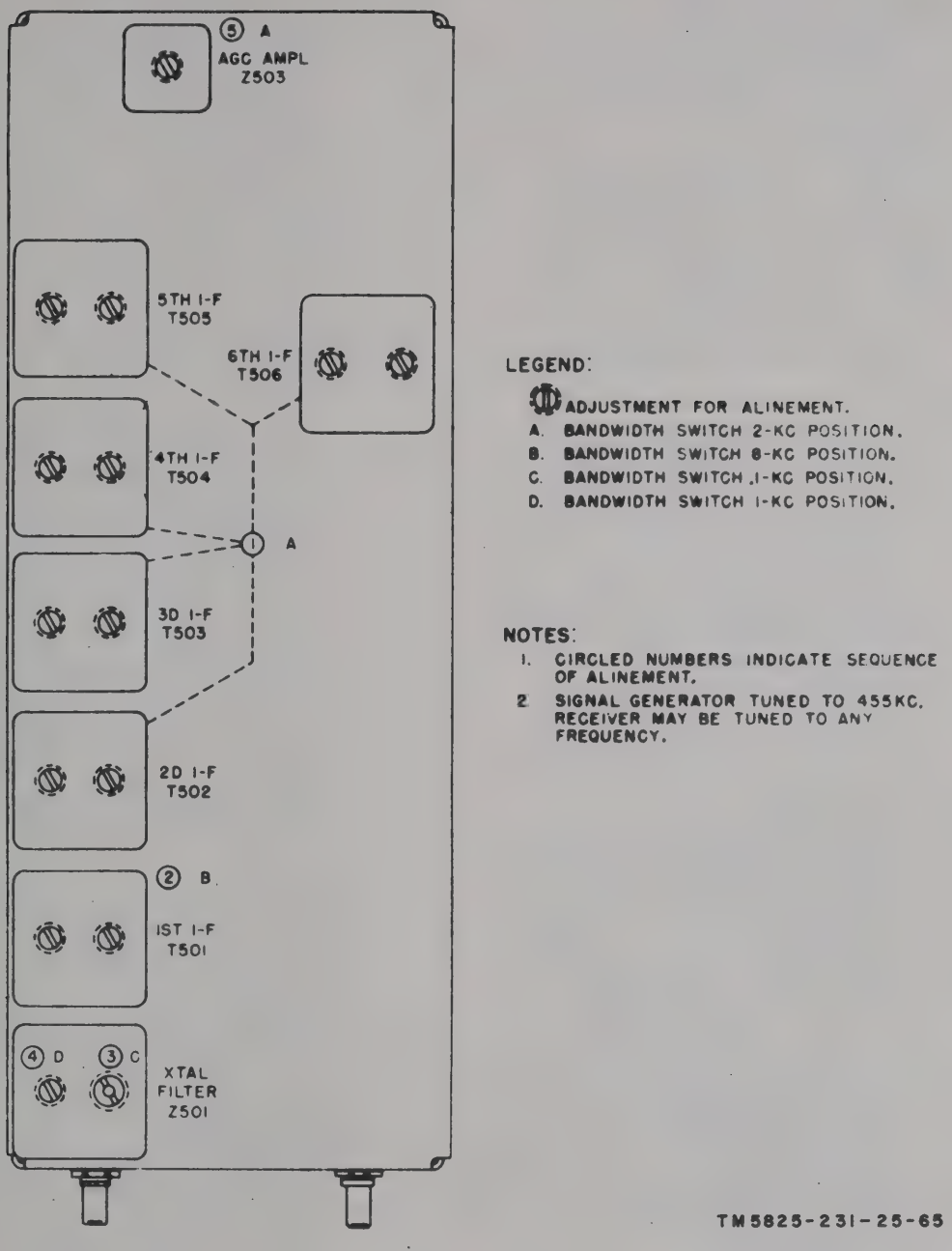


Figure 4–1. IF subchassis alignment chart.

ceiver BANDWIDTH switch to the 16-kc position. If the output reading is not yet obtained, proceed with *2*. If it is obtained, adjust the cores of transformers T506 through T501 and T207, in that order, for peak reading on the VTVM. Then, set the BANDWIDTH switch at the next lower position, and repeat the adjustment of the transformer cores for peak output. Repeat this procedure for each setting the BANDWIDTH switch until

peak output is obtained at 0.1-kc position of the switch; then proceed to (e) below.

Note. The frequency will decrease as the slugs are screwed further into the coils, and will increase as the slugs are withdrawn.

2. Perform a procedure outlined in a through e below only when the transformer cores have been displaced greatly from their normal positions within the coils. Set the BANDWIDTH switch to the 2-kc position, and proceed as follows:

   a. Tune the signal generator to 455 kc, and set the attenuator for maximum output. Remove the sixth IF amplifier tube, V506, and wrap a thin wire lead around pin 1 (grid). Replace the tube, and connect the other end of the lead to the signal generator output.

   b. Adjust the cores of transformer T506 for peak reading on the VTVM.

   c. Apply the signal generator output to the fifth i–f amplifier, V505, in the same manner as described in a above for V506, and adjust the cores of transformer T505 for maximum indication on the VTVM.

   d. Repeat the above procedure for each remaining set of i–f tubes and transformers in the following order: V504 and T504, V503 and T503, V502 and T-502, V501 and T501, and V-204 and T208.

   e. Set the BANDWIDTH switch to the 0.1-kc position, and proceed with the procedure outlined in (*e*) below.

(*e*) With the signal generator output connected to the test point, set the generator frequency at 455 kc. While adjusting the attenuator of the signal generator to maintain an output of approximately 6 volts (as read on the VTVM), carefully tune the generator to the exact frequency required to obtain peak output reading on the VTVM. Do not disturb this frequency setting while carrying out the procedures outlined in (*f*), (g), and (*h*) below. Check the setting repeatedly during these steps to make sure it has not been changed.

(*f*) Set the BANDWIDTH switch to the 2-kc position.

(*g*) Adjust the cores of transformers T506, T505, T504, T503, T502, and T208, in that order, for peak output reading, while continuously adjusting the attenuator of the signal generator to maintain a reading of approximately 6 volts on the VTVM. Repeat these adjustments until no further increase in output is noticeable.

(*h*) Change the setting of the BANDWIDTH switch to the 8-kc position, and adjust the cores of transformer T501 for maximum output. Repeat the adjustment of cores until no further increase in output can be produced.

(*i*) Return the BANDWIDTH switch to the .1-kc position.

(*j*) Set the attenuator of the signal generator for a reading of approximately 6 volts on the VTVM, and note the attenuator setting. Tune the generator in one direction, away from the frequency required for peak reading, increasing the output of the generator to restore the VTVM reading to its original value. Continue tuning the generator in this direction until the voltage output required to obtain the original reading on the VTVM is 1,000 times the voltage required at peak frequency.

(*k*) Adjust the phasing capacitor in the crystal filter, Z501, for minimum VTVM reading, and note the position of the capacitor slot.

(*l*) Tune the signal generator to the opposite side of the frequency required for peak output, and set the attenuator for increased output, as directed in (*j*) above.

(*m*) Adjust the phasing capacitor for minimum reading, and note the position; then set the capacitor approximately halfway between the two noted settings. To avoid possible incorrect readings, caused by tuning through the positions of minimum or maximum capacitance, the two settings for minimum output must be less than 45° apart.

(*n*) With the BANDWIDTH switch in the .1-kc position, tune the signal generator to obtain peak output. Set the BANDWIDTH switch to the 1-kc position. Adjust the core of the tuning coil in the crystal filter (Z501) until the frequency reading required for obtaining peak output, with the BANDWIDTH switch in 1-kc position, corresponds exactly with the frequency reading required for peak output with the BANDWIDTH switch in the 0.1-kc position. Retune the signal generator, and alternately change positions of the BANDWIDTH switch as required to complete this adjustment.

(*o*) Set the BANDWIDTH switch to the 0.1-kc position, and tune the signal generator for maximum output as described in (*e*) above. Do not disturb this frequency setting during the adjustment of the agc tuning circuit in the following steps.

(*p*) Disconnect the VTVM lead from terminal 14 of the rear terminal strip, and connect it to terminal 4 of the rear terminal strip.

(*q*) Set the FUNCTION switch to AGC, and the BANDWIDTH switch to 2-kc position.

(*r*) Adjust the core of Z503 for a maximum voltage reading on the VTVM, while adjusting the attenuator of the signal generator to maintain a peak reading of approximately 2 volts. When the adjustment is completed, disconnect the meter.

e. Alignment of the Drive, Goniometer-Rotary Coupler.

(1) No alignment adjustments are permitted at direct support maintenance level on the goniometer drive chassis except those which are authorized in chapter 2, paragraph 2–21 of TM 11–5825–231–10.

(2) If misalignment of any of the rotary units is suspected, tag the complete drive chassis appropriately and return to depot maintenance. Do not attempt disassembly of any of the rotary units.

f. Alignment of Electronic Control Amplifier. No alignment adjustments are incorporated in the electronic control amplifier. If the unit is not functioning properly, a fault exists. Refer to the troubleshooting section in chapter 3.

g. Alignment of the Monitor Oscilloscope.

(1) *General.*

(*a*) Table 4–1 lists the adjustments required following the replacement of a tube, transistor, or diode. If a part associated with an item listed in the table is replaced, check the adjustment for the listed item.

(*b*) The following is a list of test equipment required to perform the alignment procedures which follow:

Equipment	Mfr code No.	Type or model No.
AC line meter	16902	49
AC VTVM	28480	400D
Oscillator	28480	200CD
Oscilloscope	28480	541

Equipment	Mfr code No.	Type or model No.
Square wave generator	28480	211A
Time marker generator	80009	180
Vacuum tube voltmeter (with high voltage probe).	03606	WV77B
Variable transformer	58474	116

(*c*) The adjustments necessary to align the model 120B, oscilloscope are described in (2) through (6) below.

(2) *Low voltage power supply.*

(*a*) Table 4–2 lists the tolerances of the dc voltage outputs of the low voltage power supply. If any voltage is not within tolerance it is probable that the line voltage is abnormal, a malfunction has occurred, or the replacement of a tube or part has caused the misadjustment. If it is confirmed that the power supply and line voltage are normal and the voltages are not within tolerance, adjustment is then required.

(*b*) –150-volt adjustment. Using a dc VTVM, adjust potentiometer R352 (fig. 3–16) for –150 volts dc.

(*c*) +19-volt adjustment There is no adjustment for the +19-volt output; if out of tolerance a faulty transistor or part is indicated, or a fault exists in the -150-volt supply.

(*d*) +300-volt adjustment. There is no adjustment for the +300-volt output; if out of tolerance a faulty tube or part is indicated, or a fault exists in the –150-volt power supply.

(*e*) +100- and +99-volt adjustment. There is not adjustment for these outputs; if out of tolerance a faulty tube or part is indicated, or a fault exists in the –150-volt power supply.

Note. If the +300 volts dc is within tolerance and the +100 and/or +99 volts dc are not within tolerance, a fault exists in V308 or associated parts.

(3) *High voltage power supply.*

(*a*) Adjust the high voltage power supply according to (*b*) through (*g*) below.

Note. Adjustment of the high voltage affects CRT deflection sensitivity, intensity, focus, and astigmatism. Check horizontal and vertical gain adjustments following any adjustment of the high voltage. Intensity, focus, and astigmatism adjustments are included in the following adjustment of high voltage power supply.

Warning: **Voltages in excess of 2,500 volts are present in the high voltage power supply. Take all possible precautions when performing high voltage measurements.**

(*b*) Connect high voltage voltmeter between terminal 17 or 18 of transformer T302 and ground.

(*c*) Adjust potentiometer R308 (fig. 3–16) for a voltmeter reading of –2500 volts.

(*d*) Switch HORIZONTAL DISPLAY to 1 VOLTS/CM and center the spot.

(*e*) Set INTENSITY control to 9 o' clock and adjust R320 (fig. 3–16) to the point where the spot just extinguishes.

(*f*) Increase INTENSITY control and adjust FOCUS control for best spot.

(*g*) Adjust astigmatism control R316 (fig. 3–16) for small round spot readjusting FOCUS control as required.

(4) *Vertical amplifier.*

(*a*) *Balance adjustment.* Adjust the vertical amplifier balance as described below:

1. Set VERTICAL SENSITIVITY to MILLIVOLTS/CM.
2. Set vertical AC–DC to DC.
3. Short vertical input terminals.
4. While rotating vertical VERNIER back and forth, adjust BAL for no shift of spot.

(*b*) *Gain adjustment.* Adjust the vertical amplifier gain as follows:

1. Set VERTICAL SENSITIVITY to 10 MILLIVOLTS/CM.
2. Set vertical VERNIER to CAL.
3. Using voltmeter calibrator, apply a 400-cps 0.1-volt peak-to-peak signal to the vertical input terminals.
4. Adjust CAL screwdriver adjustment for a crt deflection of 10 cm.

(*c*) *Attenuator — frequency compensation and first stage neutralization adjustments.* Adjust the vertical amplifier attenuator-frequency compensation and first stage neutralization as follows:

1. Connect square wave generator to the vertical input terminals.
2. Rotate vertical VERNIER fully counterclockwise.
3. Set VERTICAL SENSITIVITY to 100 MILLIVOLTS/CM.
4. Set vertical AC–DC to AC.
5. Set HORIZONTAL DISPLAY to 0.5 MSEC/CM.
6. Adjust output of generator to 1 kc and set amplitude for 10 cm of deflection on crt.
7. Adjust capacitor C6 (fig. 3–18) for best square wave pattern on CRT.
8. Rotate vertical VERNIER to CAL.
9. Readjust square wave generator for 10 cm of deflection on CRT.
10. Adjust C9 (fig. 3–19) for best square wave pattern on CRT.
11. Repeat adjustment of C6 and C9 until best square wave pattern is obtained at the extreme vernier setting.

Note. There may be a capacitor in parallel with C9 which serves to optimize the adjustment range of C9. When changing V1 it may be necessary to alter the value of the capacitor, or add it if not present.

12. Set VERTICAL SENSITIVITY to 1 VOLTS/CM.
13. Readjust square wave generator for 10 cm of deflection on CRT.
14. Adjust capacitor C4 (fig. 3–18) for best square wave pattern on CRT.
15. Set VERTICAL SENSITIVITY to 10 VOLTS/CM.
16. Readjust square wave generator for 10 cm of deflection on CRT.
17. Adjust capacitor C2 (fig. 3–18) for best square wave pattern on CRT.

(*d*) *Third stage vertical neutralization adjustment.* Adjust the third stage vertical neutralizers as follows:

1. Rotate vertical VERNIER fully counterclockwise.
2. Set VERTICAL SENSITIVITY to 10 MILLIVOLTS/CM.
3. Set vertical AC–DC to AC.
4. Set HORIZONTAL DISPLAY to 5μSEC/CM.
5. Set TRIGGER SOURCE to INT+.
6. Turn TRIGGER LEVEL to AUTO.
7. Using square wave generator, apply a 100-kc square wave to vertical input terminals.
8. Adjust generator output to give 10-cm deflection and center the pattern vertically.
9. Using test oscilloscope, monitor the cathode of V3.
10. Adjust C12 and C13 (fig. 3–16) simultaneously, for the best square wave on both test oscilloscope and scope under test.

Note. Ignore the very fast overshoot at the leading edge as viewed on monitor scope. There may be a capacitor in parallel with C13 which serves to optimize the adjustment range of C13. When changing V2 or V3 it may be necessary to alter the value of the capacitor, or add it if not present.

(*e*) *Second stage vertical neutralization adjustment.* Adjust the second stage vertical neutralizers as follows:

1. Rotate vertical VERNIER to CAL.
2. Repeat steps *2* through *8* of (*d*) above.
3 Adjust C10 and C11 (fig. 3–16) simultaneously for best square wave on scope.

Note. There may be a capacitor in parallel with C10 which serves to optimize the adjustment range of C10. When changing V1 or V2 it may be necessary to alter the value of the capacitor, or to add it if not present.

(*f*) *Calibrator adjustment.* Adjust the output of the calibrator as follows:

1. Adjust vertical gain as described in (*b*) above.
2. Set VERTICAL SENSITIVITY to CAL.
3. Turn vertical VERNIER to CAL.
4. Set HORIZONTAL DISPLAY to 1 MILLISECONDS/CM.
5. Set TRIGGER SOURCE to INT–.
6. Turn TRIGGER LEVEL to AUTO
7. Adjust potentiometer R51 (fig. 3–16) for a CRT deflection of 6 cm.

(5) *Horizontal amplifier.*

(*a*) *Gain Adjustment.* Adjust horizontal gain as follows:

1. Set HORIZONTAL DISPLAY to 0.1 VOLTS/CM.
2. Turn horizontal VERNIER to CAL.
3. Using voltmeter calibrator, apply a 400-cps 1-volt peak-to-peak signal to the horizontal input terminals.
4. Adjust horizontal gain potentiometer R104 (fig. 3–16) for a peak-to-peak crt deflection of 10 cm.

(*b*) *Horizontal neutralizer adjustment.* Adjust horizontal neutralization as follows:

1. Set VERTICAL SENSITIVITY to 1 VOLTS/CM.
2. Turn vertical VERNIER to CAL.
3. Set HORIZONTAL DISPLAY to 0.1 VOLTS/CM.
4. Turn horizontal VERNIER to CAL.
5. Using oscillator, apply an 8-kc sine wave to vertical input terminals and the sync input of square-wave generator.
6. Using square wave generator, apply a 100-kc 1-volt peak-to-peak square wave to horizontal input terminals.
7. Adjust oscillator frequency to synchronize sine wave and square wave on CRT (stabilize presentation).
8. Adjust C103 and C104 (fig. 3–16) for best square wave response.

(*c*) *Attenuator frequency compensation adjustment.* Adjust the horizontal attenuator frequency compensation as follows:

1. Set VERTICAL SENSITIVITY to 1 VOLTS/CM.
2. Turn vertical VERNIER to CAL.
3. Turn horozontal VERNIER to CAL.
4. Set HORIZONTAL DISPLAY to 1 VOLTS/CM.
5. Using square wave generator, apply a 1-kc 10-volt peak-to-peak square wave to horizontal input terminals.
6. Using oscillator, apply an 800-cps 10-volts peak-to-peak signal to the vertical input and sycn input of square wave generator.
7. Adjust oscillator to synchronize sine wave and square wave on crt (stabilize presentation).
8. Adjust capacitor C235 (fig. 3–16) for optimum square wave on CRT.
9. Set HORIZONTAL DISPLAY to 10 VOLTS/CM.
10. Increase square wave generator output to 50 volts peak-to-peak.
11. Adjust capacitor C233 (fig. 3–16) for optimum square wave on CRT.

(*d*) *Preset Adjustment.* Adjust present as follows:

1. Set VERTICAL SENSITIVITY to CAL.
2. Set HORIZONTAL DISPLAY to 0.5 MILLISECONDS/CM.
3. Set TRIGGER SOURCE to INT+
4. Turn TRIGGER LEVEL just out of AUTO.
5. Connect dc voltmeter (100-volt range) between pin 2 of V202 and ground.
6. Adjust potentiometer R258 (fig 3–16) clockwise until CRT sweep free-runs, then counterclockwise until the sweep just stops; note the reading on the voltmeter.
7. Adjust voltage to 3 volts less negative than the last reading.

(*e*) *Trigger sensitivity adjustment.* Adjust the trigger sensitivity as follows:

1. Set VERTICAL SENSITIVITY to 100 MILLIVOLTS/CM.
2. Set HORIZONTAL DISPLAY to 5 MILLISECONDS/CM.
3. Turn both VERNIER controls to CAL.
4. Set TRIGGER SOURCE to EXT.
5. Turn TRIGGER LEVEL TO AUTO.
6. Set SWEEP MAGNIFIER to X5.
7. Set vertical and horizontal AC–DC switches to AC.
8. Connect oscillator to both the VERTICAL and HORIZONTAL inputs and set the frequency to 450 kc and amplitude to 0.16 volt rms (using model 400D/AC VTVM).
9. Adjust R203 (trigger sensitivity) fully counterclockwise.
10. Observing crt presentation, adjust R203 clockwise until the presentation becomes stable.
11. Adjust oscillator output amplitude down to 0.1 v rms, presentation should become slightly unstable between 0.15 and 0.10 v rms.
12. Set oscillator output amplitude to 0.5 v rms, and adjust frequency from 50 cps to 450 kc. Presentation should remain stable across complete frequency range.

(6) *Sweep generator.*

(*a*) *X1 Sweep Adjustment.* Adjust the X1 sweep as follows:

1. Set VERTICAL SENSITIVITY to 1 VOLTS/CM.
2. Turn vertical VERNIER to CAL.
3. Turn horizontal VERNIER to CAL.
4. Set HORIZONTAL DISPLAY to 5 MILLISECONDS/CM.
5. Set SWEEP MAGNIFIER to X1.
6. Set TRIGGER SOURCE to INT–.
7. Turn TRIGGER LEVEL to AUTO.
8. Using time mark generator, apply 100-cps time markers to the vertical input terminals.
9. Adjust X1 sweep gain R267 (fig. 3–16) to obtain 5 cycles per 10 cm on the crt.

(*b*) *Sweep time adjustment.* Adjust the horizontal sweep time as follows:

1. Set VERTICAL SENSITIVITY to 1 VOLTS/CM.
2. Turn vertical VERNIER to CAL.
3. Turn horizontal VERNIER to CAL.
4. Set TRIGGER SOURCE to INT–.
5. Set SWEEP MAGNIFIER to X1.
6. Connect time mark generator to the vertical input terminals.
7. Referring to table 4–3, adjust the time mark generator output and the HORIZONTAL DISPLAY switch to the indicated marker interval and sweep time, respectively, for each step; adjust or check for the indicated markers per cm listed in the table.

(*c*) *Sweep length adjustment.* Adjust the sweep length as follows:

1. Set VERTICAL SENSITIVITY to 100 MILLIVOLTS/CM.
2. Turn vertical VERNIER to CAL.
3. Set vertical AC–DC to AC.

4. Set HORIZONTAL DISPLAY to .5 MILLISECONDS/CM.
5. Turn horizontal VERNIER to CAL.
6. Set SWEEP MAGNIFIER to X1.
7. Set TRIGGER SOURCE to INT–.
8. Turn TRIGGER LEVEL to AUTO.
9. Adjust potentiometer R254 (fig. 3–16) for a sweep length of 10.75 cm (minimum length on any range should be 10.5 cm).

Table 4–1. Adjustments Following Tube, Transistor and Diode Replacement

Reference designation	Function	Adjustment and paragraph reference
	Vertical amplifier	
V1	Amplifier	1. Balance adjustment, para 4–4*g* (4) (*a*). 2. Gain adjustment, para 4–4*g* (4) (*b*). 3. Neutralization adjustment, para 4–4*g* (4) (*c*) and (*e*).
V2	Amplifier	1. Balance adjustment, para 4–4*g* (4) (*a*). 2. Gain adjustment, para 4–4*g* (4) (*b*). 3. Neutralization adjustment, para 4–4*g* (4) (*d*) and (*e*).
V3	Amplifier	1. Balance adjustment, para 4–4*g* (4) (*a*). 2. Gain adjustment, para 4–4*g* (4) (*b*). 3. Neutralization adjustment, para 4–4*g* (4) (*d*).
V4	Calibrator	None.
V5	Calibrator	1. Calibrator adjustment, para 4–4*g* (4) (*f*).
	Horizontal amplifier	
V101	Amplifier	1. Gain adjustment, para 4–4*g* (5) (*a*). 2. X1 Sweep adjustment, para 4–4*g* (6) (*a*). 3. Neutralization adjustment, para 4–4*g* (5) (*b*).
V102	Amplifier	1. Gain adjustment, para 4–4*g* (5) (*a*). 2. X1 Sweep adjustment, para 4–4*g* (6) (*a*). 3. Neutralization adjustment, para 4–4*g* (5) (*b*).
	Sweep generator	
V201	Trigger generator	Trigger sensitivity adjustment, para 4–4*g* (5) (*e*).
V202	Start–stop trigger	Preset adjustment, para 4–4*g* (5) (*d*).
V203	Clamp and holdoff cathode follower	None.
V204	Gate–out cathode follower	None.
V205	Sawtooth integrator and cathode follower	Sweep time adjustment, para 4–4*g* (6) (*b*).
V206		Preset adjustment, para 4–4*g* (5) (*d*).
V207		Sweep length adjustment, para 4–4*g* (6) (*c*).
V208		None.
V209		None.
CR201	Switch diode	None.
	High voltage power supply	
V301 V302 V303 V304 V305	Amplifier Oscillator Rectifier Rectifier CRT	Adjust horizontal gain, para 4–4 *g* (5) (*a*). Adjust vertical gain, para 4–4*g* (4) (*b*). Adjust sweep times, para 4–4*g* (6).
	Low voltage power supply	
V307	Regulator	None.
V308	Amplifier out–put cathode follower	None.
V309	Regulator	None.
V310	Amplifier	Adjust–150 volts, para 4–4*g* (2) (*b*).
V311	Reference tube	Adjust–150 volts, para 4–4*g* (2) (*b*).
Q301	Heater regulator	None.
CR301–CR304	Rectifiers	None.
CR305	Reference diode	None.

Table 4-2. Low Voltage Power Supply Voltages

Voltage**	Tolerance*	Typical** ripple	Typical** resistance
-150 volts dc	VTVM Accuracy (±3%)	5 mv	10K
+ 19 volts dc	-1.5 volts; +1 volt	45 mv	4K (with V101 removed)
+300 volts dc	±9 volts	45 mv	75K
+100 volts dc	±3 volts	15 mv	50K
+ 99 volts dc	±3 volts	15 mv	

*Line voltage 115 or 230 volts ac, as required.
**With respect to chassis ground.

Table 4-3. Horizontal Sweep Time Adjustment

Step	Marker interval	Sweep time	Adjust	Markers per 10 cm
1	10 μsec	5 μSEC/CM	C227	5
2	10 μsec	10 μSEC/CM	C227 *	10
3	10 μsec	20 μSEC/CM	C227 *	20
4	100 μsec	50 μSEC/CM	C225	5
5	100 μsec	100 μSEC/CM	C225 *	10
6	100 μsec	200 μSEC/CM	C225 *	20
7	1 ms	.5 MILLISECONDS/CM	C223	5
8	1 ms	1 MILLISECONDS/CM	C223 *	10
9	1 ms	2 MILLISECONDS/CM	C223 *	20
10	10 ms	5 MILLISECONDS/CM	R267	5
11	10 ms	10 MILLISECONDS/CM	R267 *	10
12	10 ms	20 MILLISECONDS/CM	R267 *	20
13	100 ms	50 MILLISECONDS/CM	R247	5
14	100 ms	100 MILLISECONDS/CM	R247 *	10
15	100 ms	200 MILLISECONDS/CM	R247 *	20

*Do not adjust if indication is within ±0.5 cm of that listed in the "markers per 10 cm" column.

h. Alignment of Power Distribution Panel. No adjustments for the purposes of alignment are required in the power distribution unit.

i. Alignment of Radio Transmitter T-279A/UR.

(1) The following items of test equipment are required to align the radio (target) transmitter.

(*a*) Multimeter (VOM), Simpson model 260.

(*b*) Radio Receiver R-725/URR, one of the receivers provided with the Direction Finder Set AN/TRD-15.

(2) Theory of alignment of Radio Transmitter T-279A/UR.

(*a*) Radio Transmitter T-279A/UR includes an RF oscillator followed by an RF amplifier. These two stages should track or tune together to the same resonant frequency for proper operation. With normal use of the transmitter it is possible that one or more coils may require realignment at some time.

(*b*) For proper tracking, the RF oscillator and RF amplifier stages should have equal minimum capacities, and the inductances should be equal. The whip antenna is connected to the RF amplifier tuned circuit, therefore, the antenna capacitance of about 30 μμf is in parallel with the tuning capacitor C612. Since the two ganged tuning capacitors have equal minimum capacities, trimmer capacitor C602 is connected in parallel with the oscillator tuning capacitor so that its minimum capacity can be adjusted to match the minimum capacitance of the RF amplifier stage. This capacitor determines the band-

width or frequency ratio covered on each band, and should not be readjusted unless absolutely necessary. If capacitor C602 is not properly adjusted, it will be impossible to align any of the coils so that the two stages tune together at both ends of the band.

(*c*) The frequency range of each RF oscillator coil is made to coincide with the dial calibration by means of a tuning slug in each coil. If the mechanical coupling between the dial drive and variable capacitor has not been tampered with incorrect frequency calibration of the tuning dial indicates that realignment of the RF oscillator coils is necessary.

(*d*) After alignment of the RF oscillator coils ((3) below), or when the current drawn by the RF amplifier stage is excessive, the RF amplifier coils must be realigned. The current drawn by the RF amplifier may be measured by disconnecting the +135-volt lead from the battery terminal strip and inserting a VOM (set to 100 ma scale) in series with the circuit. The transmitter should be turned on, with the MCW–CW switch in the CW position. Turn the OUTPUT knob fully clockwise for the maximum output. With new batteries, current readings at various frequencies should be close to those shown in the table below:

Frequency (mc)	Current (ma)
.5	6.5
1	5
1	6
2	6
2	7
4	7
4	9
8	8
8	13
16	11
16	17
32	16

(3) Alignment of RF oscillator V601.

(*a*) Set the TRANSMITTER switch to the OFF position. Turn the radio transmitter on its side and remove the four knurled holddown screws on the bottom of the case. Pull the chassis assembly out of the case.

(*b*) Extend the antenna to maximum height and set the TRANSMITTER switch to the ON position, the MCW–CW switch in the CW position, and turn the OUTPUT control fully counterclockwise. Refer to instructions contained in TM 11–688. Set the controls on the radio receiver to receive the cw signal from the radio transmitter.

(*c*) Set the MEGACYCLE CHANGE and KILOCYCLE CHANGE controls on the radio receiver to obtain a reading of 0.5 mc on the frefrequency indicating dial. Set the BANDSWITCH on the radio transmitter in the 0.5–1MC position and adjust the tuning control to read 0.5 mc on the tuning dial.

(*d*) Adjust the tuning slug of L601 until the radio transmitter signal received by the radio receiver is maximum as indicated by maximum deflection of the LINE LEVEL and CARRIER LEVEL meters on the radio receiver.

(*e*) Set the tuning control on the radio transmitter to read 1 mc on the tuning dial and set the MEGACYCLE CHANGE and KILOCYCLE CHANGE controls on the radio receiver to read 1 mc on the frequency indicating dial. If the radio transmitter dial is incorrect at the opposite end of the dial, and incorrect setting of C602 is indicated.

Note. When capacitor C602 is not correctly adjusted, it will be impossible to make the dial calibrations correspond to the rf oscillator frequency on any band. Do not disturb the adjustment of C602 until the other bands have been checked ((f) below).

(*f*) Repeat procedures given in (*d*) and (*e*) above for the band, frequencies, and coils shown in the table below. The BANDSWITCH position discussed above is included in the table.

Bandswitch position	Calibration frequencies (mc)	Coil
.5–1MC	.5	L601
.5–1MC	1	
1–2MC	1	L602
1–2MC	2	
2–4MC	2	L603
2–4MC	4	
4–8MC	4	L604
4–8MC	8	
8–16MC	8	L605
8–16MC	16	
16–30MC	16	L606
16–30MC	30	

(*g*) If the RF oscillator does not correspond to the dial calibration on any band, adjust capacitor C602 as follows: If the RF oscillator frequency is too great, increase C602 until the range covered by the RF oscillator is decreased to the range shown on the dial; if the RF oscillator range is too narrow, decrease C602 until the range covered by the RF oscillator is increased to the range shown on the dial.

(*h*) After all bands have been aligned, recheck the frequency of each coil. Turn the TRANSMITTER switch to the OFF position.

(4) Alignment of RF amplifier V602.

(*a*) Insert VOM in the positive 135-volt line as directed in (3) (*d*) above. Extend the antenna to maximum height.

(*b*) Set the TRANSMITTTER switch in the ON position, the MCW–CW switch in the CW position, and turn the OUTPUT knob clockwise for maximum output.

(*c*) Set the BANDSWITCH on the 0.5–1MC position and vary the tuning control to read 5 mc on the tuning dial. Vary the tuning slug of L607 to obtain minimum plate current as read on the VOM.

(*d*) Vary the tuning control to obtain a reading of 1 mc on the tuning dial and check to see that L607 also is tuned at this frequency for minimum plate current by varying the slug. If the two adjustments differ slightly, readjust the slug of L607 by a small amount so that the the plate currents are equal on both frequencies.

(*e*) Repeat procedures given in (*c*) and (*d*) above for the bands, frequencies, and coils shown in the following table:

Bandswitch position	Calibration frequencies (mc)	Coil
.5–1MC	.5	L607
.5–1MC	1	
1–2MC	1	L608
1–2MC	2	
2–4MC	2	L609
2–4MC	4	
4–8MC	4	L610
4–8MC	8	
8–16MC	8	L611
8–16MC	16	
16–30MC	16	L612
16–30MC	30	

Section III TROUBLESHOOTING AND REPAIR
GENERAL SUPPORT MAINTENANCE

4–5. General Maintenance Information

Skills and equipment normally available to organizational and direct support maintenance personnel are adequate to troubleshoot and repair the AN/TRD–15 DF set, except for the drive, goniometer-rotary coupler. Troubleshooting and repair of the drive, goniometer-rotary coupler subchassis is described in depot maintenance repair except for its relay components. Troubleshooting and repair of these relay components and all other subchassis of the AN/TRD–15 are fully covered in the organizational and direct support maintenance descriptions in this manual. Effectively, general support maintenance is not applicable to the AN/TRD–15 DF set.

4–6. Adjustments Procedures

All adjustment procedures for the AN/TRD–15 are described fully in the organizational and direct support adjustment sections of this manual.

CHAPTER 5

GENERAL SUPPORT TESTING PROCEDURES

5-1. General

All testing necessary for determining minimum operational capability of the AN/TRD-15 DF set and its subchassis are fully described in the bench test procedures set forth in the direct support maintenance section of this manual. Those tests are necessary to complete satisfactory repair at the direct support maintenance level. Effectively, general support testing procedures are not applicable to the AN/TRD-15 DF set.

5-2. Modification Work Orders

No modification work orders are applicable to the AN/TRD-15 Direction Finder Set.

CHAPTER 6

DEPOT MAINTENANCE

6–1. General

Disassembly and repair of components of the drive, goniometer-rotary coupler subchassis is a highly complex operation, principally from a mechanical standpoint. Improper mechanical repair of this assembly could cause electronic problems that might be difficult to analyze as well as damage to moving parts. For this reason, only well qualified personnel with proper tools and equipment normally utilized in higher category maintenance should disassemble this subchassis. The repairman must have a goniometer stator spacing tool, SCA–T3908 (92110) to reassemble and center the goniometer stator.

a. Careful handling of the drive, goniometer subchassis is required in both shop and when in transit to or from repair facilities, since several items are factory-set to specific tolerances. Careful handling will prevent return of this equipment to depot for avoidable out-of-tolerance repair.

b. Two major functional areas are covered; troubleshooting and disassembly of mechanical-electrical assemblies.

c. Special emphasis is placed on isolation ot troubles to a particular defective assembly. Avoid unnecessary disassembly of the drive mounting plate, which must be disassembled only if the two drive housings, the motor, or the rotary coupler stator are to be replaced. It is recommended that correction by substitution with known good assemblies be an accepted procedure. Assemblies which are suspected of being defective can often be substituted in a servicable AN/TRD–15 DF set to determine if the assembly is indeed defective. However, proceed with caution and insure that the defective assembly will not damage the good DF set.

d. It is assumed that the drive, goniometer-rotary coupler subchassis has been removed from the AN/TRD–15 rack and is in a shop for repair. Both goniometers, the magnetic sync pulse generator assembly, and the rotary coupler stator can be taken from their mounts separately. Therefore, disassemble only as far as necessary to replace or repair the defective component.

6–2. Troubleshooting the Goniometers, Drive, Rotary Coupler, Magnetic Syncronization, and Pulse Generator Assemblies

Refer to figure 6–17 for schematic diagram. The only test equipment required is a 260 VOM.

a. Troubleshooting Procedures. Malfunction in the goniometers, drive, sync, pulse, and rotary coupler assemblies will be indicated by deviations from normal operation on the azimuth indicator or monitor scope. These deviations, their causes and corrective action to repair the maufunction are listed in the troubleshooting chart (*c* below). Perform recommended remedies in their listed order.

b. Major Components. Refer to figure 3–13 for location of major components of the drive, goniometer-rotary coupler subchassis. Figures 6–1 and 6–2 are exploded views.

c. Troubleshooting Chart. Primary goniometer (A1) or secondary goniometer (A3), rotary coupler (A2), and magnetic sync assembly (E3).

Item	Trouble	Probable cause	Remedy
1	Monitor scope not operating properly; waveform keeps drifting when in EXTERNAL TRIGGER position.	Remote synchronization malfunction.	Tighten set screws in flexible coupler MP23. Replace sync magnet E12. Replace sync rotor, MP5. Check sync stator L1 for open coil. If not open and trouble persists, change L1 (para 6–3 *c*).
2	Erratic indication on monitor scope or no indication.	Output limiting of sync assembly.	Check R1, C1, CR1 and CR2. Replace defective component (para 6–3 *c*). Open or shorted sync stator L1. Replace (para 6–3 *c*).
3	DF "on course" changes; sense pattern proper on azimuth indicator.	Goniometer flexible coupler slipping.	Tighten 4 setscrews on flexible coupler (MP23).
4	No RF to receiver	Shorted or open rotary coupler coil in E3, rotor or E1, stator.	Tighten timing belt pulley setscrews (MP21). Check for less than 1 ohm resistance in coils of rotary coupler. Replace rotor or stator if open. Due to low resistance, check shorts by substitution with known good assembly.
5	Stationary line on azimuth indicator instead of circular pattern.	No power from electronic control amplifier.	Check for 115 volts, 180 cycle input. If not available, trouble is in electronic control amplifier. If input is available, check for shorted or open power leads to goniometer drive motor (B1).
6	Dot on scope	Goniometer rotor coil open, or T1 coupling coils open.	Check for open in coils of goniometer. Resistance of coils should be less than 1 ohm. Shorts may be checked by substituting a serviceable goniometer. **Note.** If coil is defective, complete rotor (E9), stator (E11) or stator of T1 must be replaced.
7	North-south line on scope	Goniometer E-W stator coil open.	Same remedy as 6.
8	East-west line on scope	Goniometer N-S stator coil open.	Same remedy as 6.

6–3. Replacement of Parts, Disassembly, Repair and Reassembly

a. Removal of Goniometers. Primary and and secondary goniometers are interchangeable, and removed in the same manner.

(1) Loosen two Allen head setscrews (14, fig. 6–1) on flexible goniometer coupler (13) and loosen coupling from goniometer shaft (12) inside drive housing (22), visible through access holes.

(2) Remove two hex head bolts (21) from goniometer mounting slots (3).

(3) Pull out goniometer.

b. Replacement of Goniometer. Replace in reverse sequence to the order of removal. Be sure to replace flexible coupling (13) on goniometer shaft snug to goniometer shaft bearing (11).

c. Disassembly and Repair of the Magnetic Sync Pulse Generator Assembly (fig. 6–1).

(1) Loosen two Allen head setscrews (19) on pulley (20) in the secondary goniometer drive housing (22).

(2) Loosen four mounting clamps (24) on rear mount of secondary goniometer drive housing (22).
(3) Remove sync housing (27) from rear of secondary goniometer drive housing (22).
(4) Remove six screws (28) from backplate (34) of sync assembly. Remove plate. R1, C1, CR1 and CR2 are located inside the housing.
(5) Remove retaining ring (29) holding shaft (31) in sync assembly housing (22).
(6) Remove bearing spacer (30) from shaft (31). Pull rotor (33) free.
(7) Remove and replace sync magnet (32) on rotor if defective (determine by substitution).
(8) To remove L1, remove stator coil housing (26), by loosening Allen head setscrew holding stator coil housing, unsoldering leads, and pushing coil housing (27). Remove screws holding coil in housing and replace coil.

d. Reassembly of Sync Assembly (fig. 6–1).

(1) Replace stator coil housing (26) in sync housing (27) until it touches the sync rotor (33), then back housing off rotor .025 inches maximum. (Coil should be no further than .025 inches from sync rotor.) Resolder leads to coil.
(2) Replace spacer bearing (30) on sync assembly shaft (31).
(3) Replace sync assembly shaft (31) in sync housing (27) and replace retaining ring (30).
(4) Replace sync assembly in drive housing (22).
(5) If secondary goniometer was removed prior to removing sync assembly, replace timing belt on pulley (20). To adjust timing belt, refer to *f* below.

Note. It is not necessary to remove secondary goniometer to disassemble sync assembly. If secondary goniometer is not removed, belt will stay on pulley which will be held in position from rear by secondary goniometer flexible shaft coupler (13).

(6) Replace pulley (20) inside secondary goniometer drive housing (22) on sync assembly shaft (31) Space pulley (20) on shaft (31) 1/4 inch from inside rear wall of secondary goniometer drive housing (22).
(7) Tighten two Allenhead setscrews (16) in pulley (20) until pulley fits firmly on sync assembly shaft (32) in secondary goniometer drive housing (22). (Use access holes.)

e. Removal and Replacement of E1, Rotary Coupler Stator (fig. 6–2).

(1) Remove five screws (5) from rear of rotary coupler stator (1).
(2) Remove rotary coupler stator (1) from rotary coupler housing.
(3) Remove two spacing shim plates (2).

Note. This coil assembly is molded with potting compound, and is not repairable if defective.

f. To Remove and Replace Timing Belt.

(1) Remove goniometers in accordance with *a* above.
(2) Loosen setscrews (14), fig. 6–1) and (21), fig. 6–2 on both goniometer flexible shaft couplers and remove couplers.
(3) Loosen setscrews (fig. 6–1 (19)) on timing belt pulley in secondary goniometer drive housing and remove pulley from shaft.
(4) Refer to figure 6–2 and remove timing belt (19) from pulley (28) through primary goniometer drive housing (16) access holes. Replace with new timing belt.
(5) Place new timing belt on pulley (20, fig. 6–1) in secondary goniometer drive housing (22) and replace pulley on sync assembly shaft (31).
(6) Loosen four bolts from (23) on secondary drive housing mount from bottom of chassis.
(7) Set belt tension by adjusting position of secondary goniometer drive housing (22) on drive mounting plate (18) so top and bottom loops of belt are parallel to each other and to mounting plate (no sagging). If belt

is too loose, it will cause vibration and if too tight, motor B1 will not operate at proper sync speed.

(8) When proper tension on timing belt is attained, retighten four mounting bolts of secnndary goniometer drive housing from bottom of chassis.

(9) Replace goniometers in accordance with *b* above.

g. Disassembly of Goniometer (fig. 6–1).

(1) Remove three screws from holes (10) in goniometer shaft retaining plate (9). Retaining plate, shaft bearing (11) and shaft (12) are removed as a unit.

(2) Tap out shaft (12) from shaft bearing (11) in retaining plate (9).

(3) Remove E9, goniometer rotor assembly (8).

(4) Remove spring tension washer (5) which prevents goniometer rotor from binding on rear of goniometer housing (1).

(5) Replace shaft of new goniometer rotor (12) in shaft bearing (11) in same position as defective rotor.

(6) Rotor is not repairable; entire rotor must be replaced if defective. (It is recommended that test by substitution be made if coils are not open when checked with a voltmeter. Since they would measure less than 1 ohm resistance, it is not feasible to check for shorted coils.

Caution: **To disassemble the goniometer further is not recommended unless goniometer spacing tool, SCA–T3908 is available to enable accurate centering of the goniometer stator in the goniometer housing. The rotor of the goniometer rotor assembly must be accurately spaced for proper rotation in the stators. In the event the tool is available to perform this spacing operation upon reassembly of the goniometer, the remainder of the steps can be performed to replace either one or both stator coils. If spacing tool is not available, it is necessary to replace the goniometer housing, goniometer stator, and T1 coupling coil stator as a unit.**

(7) If no further tear down of the goniometer is required, reassemble goniometer in reverse sequence to the order of disassembly.

(8) To continue disassembly, remove the six screws from the goniometer sideplate mounting holes (28, fig. 6–2).

(9) Tag uninsulated wire leads (for identification on replacement) to connectors J1, J2, J3, J4 (26) and J5 (31). Unsolder at connector terminals.

(10) Remove six screws holding top plate (32) of goniometer to housing and remove plate.

(11) Unsolder tagged wire leads from goniometer stator (29) and T1, coupling coil (30). Leads are visible inside goniometer housing. (Do not take leads off coupling coil if T1, coupling stator, is not replaced.)

(12) Remove two screws holding ground posts to inside wall of goniometer housing. This disconnects black wire ground leads from stator to housing.

(13) Remove three slotted head screws (27) one is located at bottom center of goniometer housing; the other two are located on inside center brackets exactly 4 inches behind the mounting slots. These screws hold the goniometer stator in fixed position.

(14) Loosen three Allen head setscrews (25); one is located at bottom center of goniometer housing; the other two are located on center brackets inside goniometer housing 1 3/4 inches behind the mounting slots.

(15) Remove goniometer stator (29) through front of housing.

(16) To remove stator of T1 (30) remove three screws in mounting face of stator attaching it to inside rear of goniometer housing. A long screwdriver must be inserted in the front opening of the goniometer housing in order to reach these screws.

(17) Remove T1 stator and replace.

h. Reassembly of Goniometer (fig. 6–2).

(1) Resolder leads to T1 stator (30) in rear of goniometer housing, if coil was replaced.

(2) Insert new goniometer stator in same position as original stator through front of goniometer housing and partially screw the mounting screws (27) (removed in *g* above, into stator. Stator screw hole locations prevent misorientation of stator in goniometer housing.

(3) Insert teflon shaft of spacing tool SCA–T3908 into front opening of goniometer stator where rotor would normally be inserted. Press in firmly until outside diameter of metal plate on tool fits flush against recessed lip of goniometer mounting face (21). (This face is identified by the three screw holes used for attaching rotor shaft retaining plate to front of goniometer housing.)

(4) Adjust Allen head setscrews (25), one outside bottom center and two recessed inside of goniometer housing on brackets 1 3/4 inches to the rear of mounting slots. Gradually adjust each setscrew, in turn, until clearance between the outside diameter of the metal face of the spacing tool is exactly .004 inches from recessed diameter of goniometer mounting face (24) for goniometer shaft retaining plate (23).

(5) When clearance around the outside diameter of the tool mounting plate is .004 inch, the goniometer stator is properly centered.

(6) Screw the three rear mounting screws (27) tight. Recheck for .004 inch clearance.

(7) Remove spacing tool.

(8) Solder black ground leads from stator to ground posts and remount ground posts inside goniometer housing.

(9) Replace top cover plate (32) on goniometer housing.

(10) Resolder leads to J1, J2, J3, J4 (31) and J5 (36).

(11) Replace sideplates on goniometer housing.

(12) Replace bearing (11, fig. 6–1) in goniometer shaft retaining plate (9) and goniometer shaft (12) in bearing.

Caution: **Exercise care in next step as rotor will bind if spring washer (5) is replaced in reverse.**

(13) Stand goniometer on end with mounting slots (3) facing up.

(14) Place a long pencil in goniometer extending from the bottom end of the T1 stator up through the goniometer face.

(15) Place spring washer (5) on a long pencil, with 4 spring points facing up.

(16) Allow washer to drop into center rear of T1 stator with points facing upward.

(17) Observe that washer is seated against bottom of goniometer housing, inside T1 stator, with spring points facing upward. Carefully withdraw pencil without disturbing washer position.

(18) With spring washer properly in place, insert goniometer rotor assembly (8).

(19) Goniometer rotor shaft bearing (6) will rest against points of spring washer (5).

(20) Rotate rotor shaft and check that rotor does not bind. If it does, repeat (4) through (19) above.

(21) Replace three screws attaching goniometer shaft retaining plate to housing face.

i. Removal of Components from Drive Mounting Plate.

Caution: **This disassembly is necessary only for repair or replacement of the following: rotary coupler housing or rotor, the drive motor, the primary or secondary drive assemblies.**

(1) Remove motor power connector plug (11) from chassis connector J2.

(2) Remove goniometers in accordance with *a* above.

(3) Remove four bolts from top and 16 nuts from bottom of drive, goniometer-rotary coupler chassis attaching shock mounting plate (17, fig. 6–1) to chassis and remove from chassis.

(4) Remove two bolts holding angle bracket to shock mounting plate (17).

(5) Use screwdriver to pry drive mounting plate (18) from shock mounting plate (17). Care should be exercised so rubber shock absorbers (16) on shock mounting plate are not damaged.

Note. Considerable pressure is necessary to separate the mounting plate from shock mounts. To replace mounting plate, C-clamps must be used on all four corners to obtain enough pressure to firmly seat plate in rubber shock mounts.

(6) Remove six bolts from bottom of drive mounting plate (18) holding primary drive housing, motor, and rotary coupler housing.

(7) Loosen Allen head setscrews holding flexible coupler (20, fig. 6–2) and pulley (18) on the motor shaft (14) in primary goniometer drive housing (16). Note that pulley clearance from rear drive housing wall is 1/4 inch.

(8) Remove timing belt (19) from pulley (18).

(9) Remove belt, pulley, and flexible coupler from inside primary goniometer drive housing (16) through access hole.

(10) Remove four bolts (13) on inside primary goniometer drive housing motor mounting surface attaching motor to primary drive housing (16).

(11) Remove primary goniometer drive housing (16).

(12) Remove five bolts (7) from sync motor (12) attaching it to rotary coupler housing (6) adn remove motor.

(13) Remove Allen head setscrew in locknut (8) holding rotary coupler rotor shaft (4) in place in rotary coupler housing (6).

(14) Remove locknut (8).

(15) Remove rotary coupler rotor assembly (3).

j. Reassembly. Reassemble in reverse sequence to the order of disassembly, making certain that pulley face (18) has 1/4 inch clearance from drive housing walls, and that goniometer flexible couplers are snug against goniometer rotor bearing in goniometer shaft retaining plate.

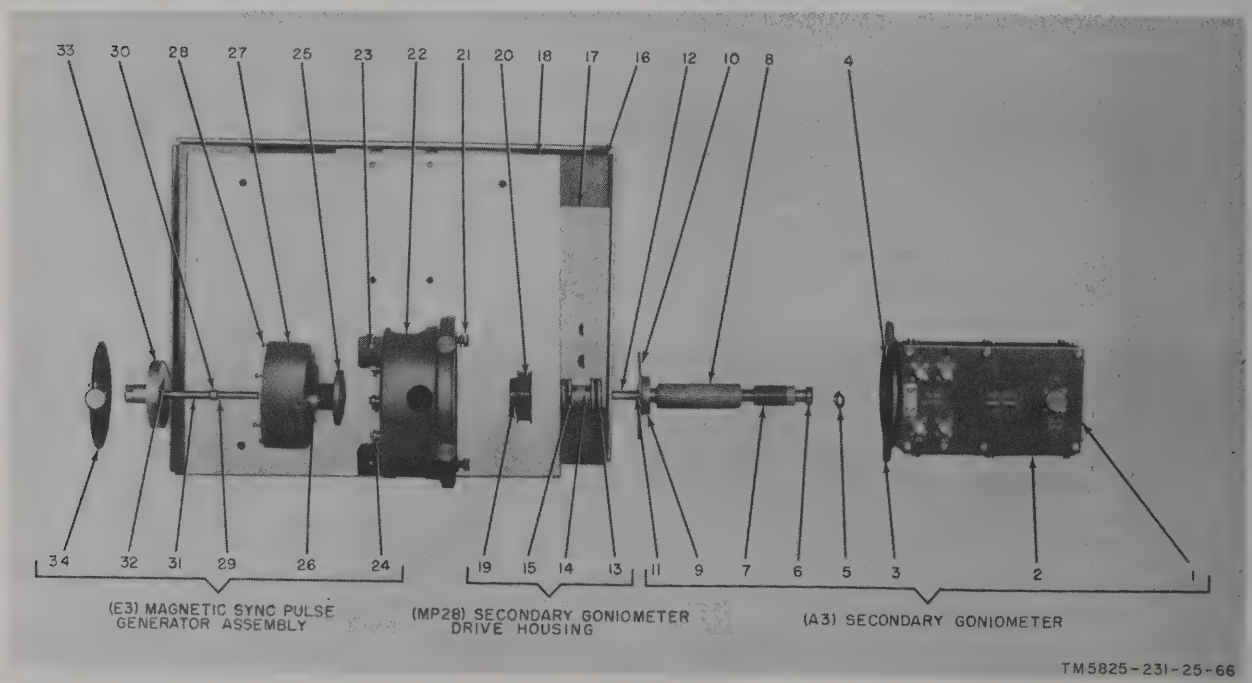
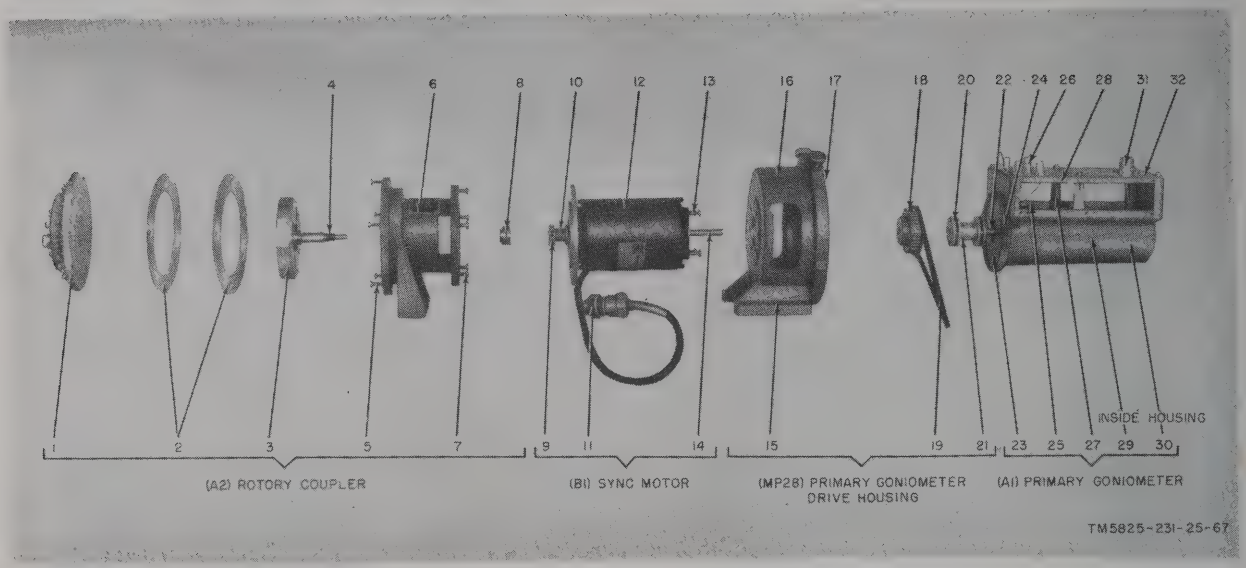


Figure 6–1. Secondary goniometer, drive housing, and sync assembly, exploded view (top).

Item	Name	No. per unit	Ref. symbol
1	Housing, goniometer	1	MP1A
2	Plate, goniometer side	2	MP40
3	Slot, mounting (for MP32)	2	
4	Hole, mounting (for MP43 in MP1A face)	3	
5	Washer, spring	1	MP45
6	Bearing, rear goniometer shaft	1	MP14
7	Coil, coupling (rotor of T1)	1	
8	Rotor assembly, goniometer	1	E9
9	Plate, shaft retaining, goniometer	1	MP41
10	Holes, mounting (for MP42 screws)	3	
11	Bearing, front goniometer shaft	1	MP15
12	Shaft, goniometer (part of E9)	1	
13	Coupler, flexible	1	MP23
14	Set screw (in MP23)	2	
15	Set screw (in MP23)	2	
16	Mount, rubber shock	4	MP29
17	Plate, shock mounting	1	
18	Plate, drive mounting	1	MP17
19	Set screw (in MP21)	2	
20	Pulley, timing belt	1	MP21
21	Bolt, hex	2	MP32
22	Housing, drive, secondary goniometer	1	MP28
23	Hole, mounting (in MP28)	4	
24	Clamp, mounting	4	MP30
25	Flange, mounting, sync assembly	1	MP8
26	Housing, sync stator (houses coil L1)	1	MP8A
27	Housing, sync assembly	1	MP34
28	Screw, mounting, sync housing	6	MP35
29	Ring, shaft retaining	1	MP14
30	Bearing, spacer	1	MP6
31	Shaft, sync assembly	1	MP7
32	Magnet, sync rotor	1	E12
33	Rotor, sync assembly	1	MP5
34	Plate, sync assembly back	1	MP36

Figure 6-1—Continued.



Item	Name	No. per unit	Ref. symbol
1	Stator, rotary coupler (input coils)	1	E1
2	Plate, shim spacing	2	MP8
3	Rotor assembly, rotary coupler (output coils)	1	E3
4	Shaft, rotor (threaded for MP9)	1	MP2
5	Screw, stator mounting	5	MP46
6	Housing, rotary coupler	1	MP2A
7	Bolt, rear motor mounting	5	MP31
8	Nut, lock	1	MP9
9	Coupler, flexible	1	MP24
10	Set screw (in MP24)	4	
11	Connector, plug, electrical	1	P1
12	Motor, synchronous	1	B1
13	Bolt, front motor mounting	4	MP33
14	Shaft, motor (part of B1)	1	
15	Hole, housing mount (base of MP28)	4	
16	Housing, drive, primary goniometer	1	MP28
17	Face, mounting (of MP28)	1	
18	Pulley, timing belt	1	MP21
19	Belt, timing	1	MP22
20	Coupler, flexible	1	MP23
21	Setscrew (in MP23)	4	
22	Shaft, goniometer (part of rotor E9)	1	
23	Plate, shaft retaining, goniometer	1	MP41
24	Face, goniometer mounting (part of MP1A)	1	
25	Set screw, goniometer stator adjusting	3	MP39
26	Connector, RF, goniometer stator	4	J1, J2, J3, J4
27	Screw, goniometer stator mounting	3	1 of MP37; 2 of MP38
28	Hole, goniometer side plate mounting	6	
29	Stator, goniometer (inside housing)	1	E11
30	Stator, coupling coil (inside housing, part of T1)	1	
31	Connector, RF, T1 stator	1	J5
32	Plate, goniometer top cover	1	MP43

NOTES

1—Goniometer rotor assembly contains goniometer rotor coil and rotor coil of coupling transformer T1.
2—Stator coil of coupling transformer T1 is located on inside rear of goniometer, and has same reference symbol as rotor.

Figure 6–2. Primary goniometer, drive housing, motor, and rotary coupler, exploded view (side).

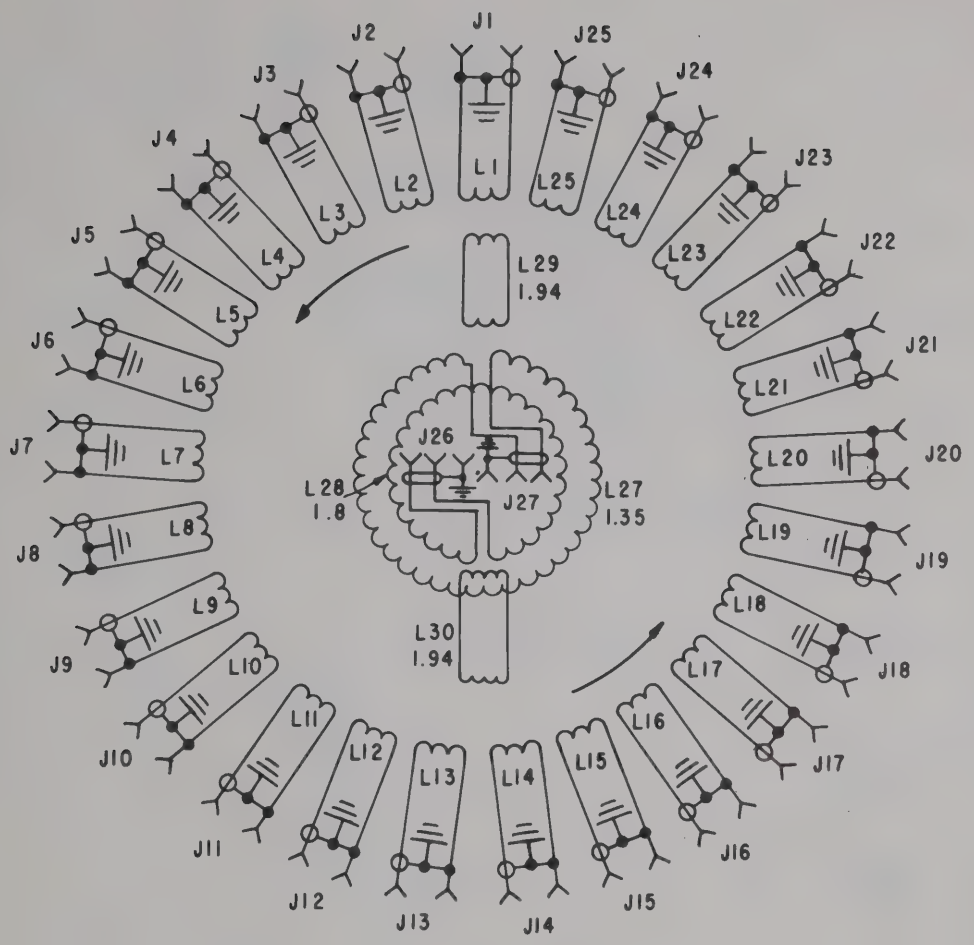


Figure 6-3. Rotary coupler, schematic diagram.

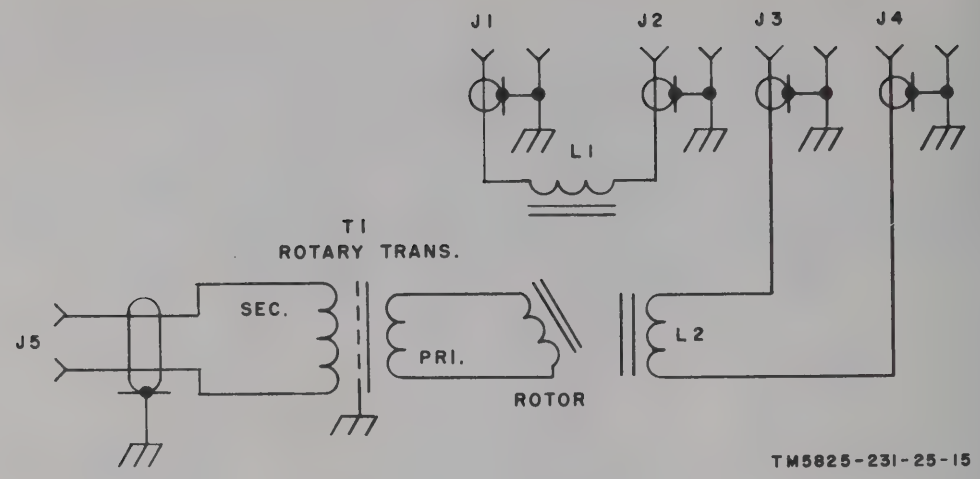


Figure 6-4. Electrical goniometer, schematic diagram.

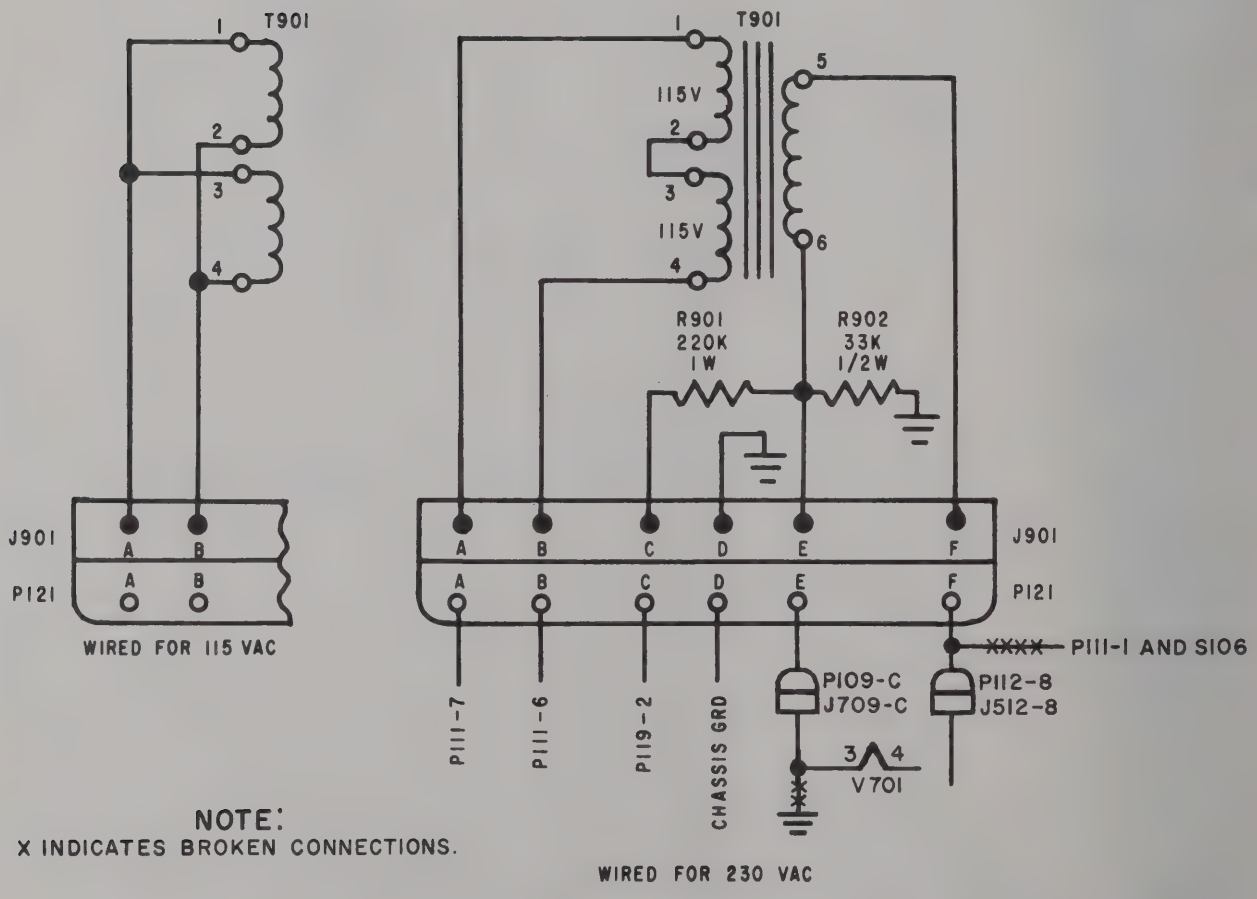


Figure 6-5. R-390A/URR receiver modification.

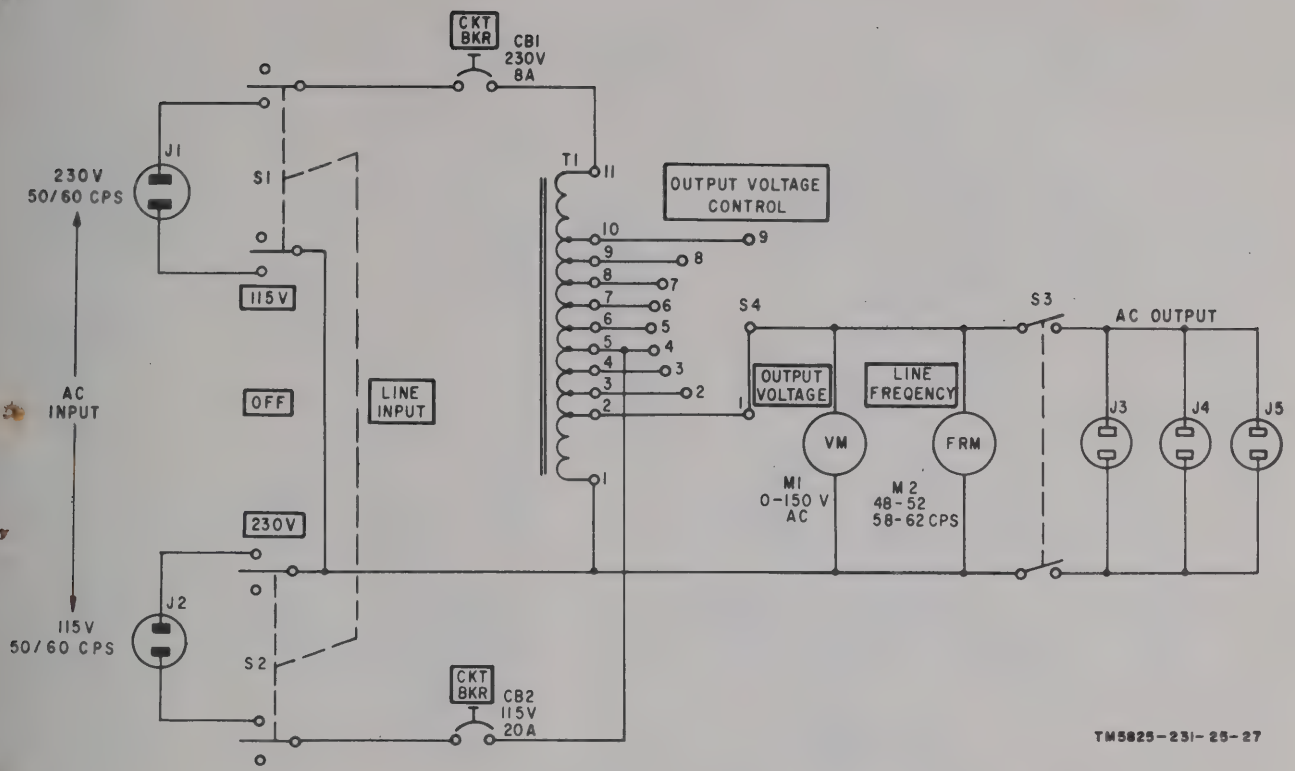


Figure 6–6. Power distribution panel, schematic diagram.

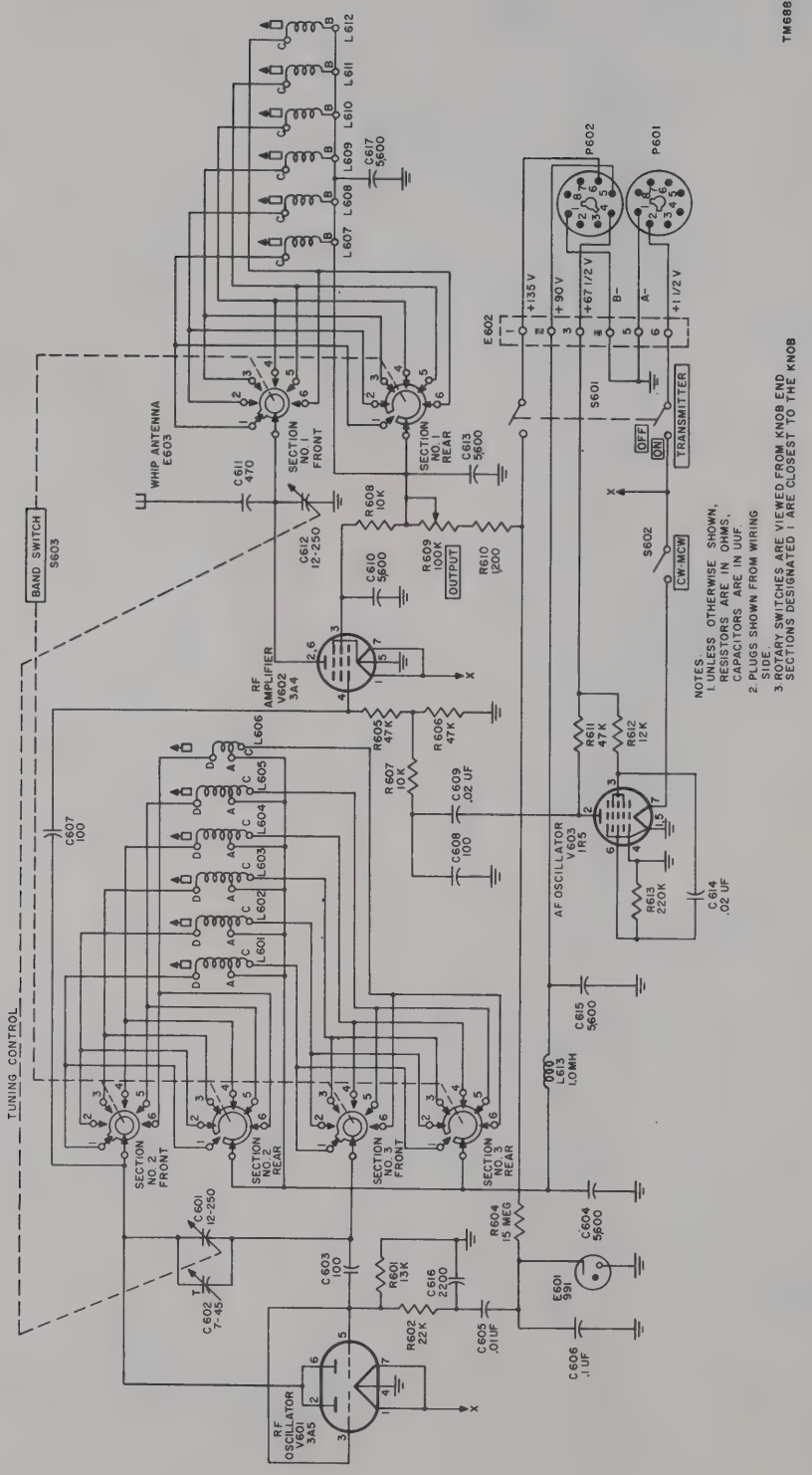
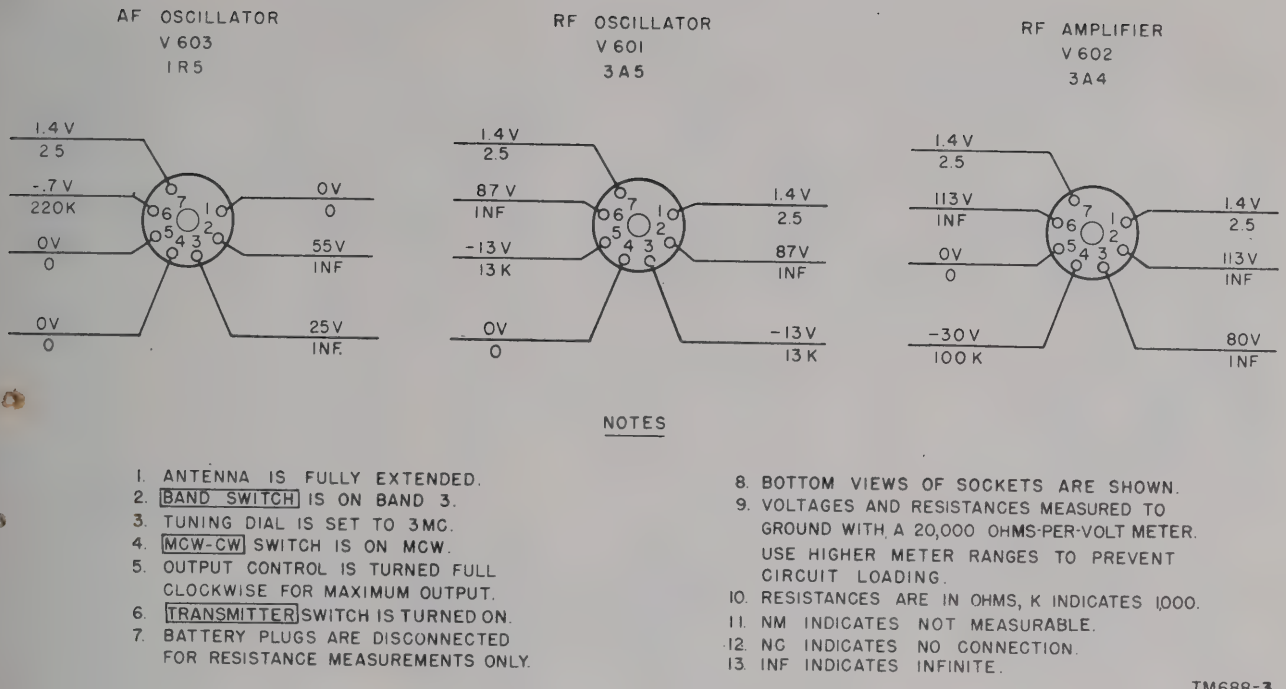


Figure 6-7. Radio Transmitter T-279/UR, schematic diagram.



NOTES

1. ANTENNA IS FULLY EXTENDED.
2. BAND SWITCH IS ON BAND 3.
3. TUNING DIAL IS SET TO 3MC.
4. MCW-CW SWITCH IS ON MCW.
5. OUTPUT CONTROL IS TURNED FULL CLOCKWISE FOR MAXIMUM OUTPUT.
6. TRANSMITTER SWITCH IS TURNED ON.
7. BATTERY PLUGS ARE DISCONNECTED FOR RESISTANCE MEASUREMENTS ONLY.
8. BOTTOM VIEWS OF SOCKETS ARE SHOWN.
9. VOLTAGES AND RESISTANCES MEASURED TO GROUND WITH A 20,000 OHMS-PER-VOLT METER. USE HIGHER METER RANGES TO PREVENT CIRCUIT LOADING.
10. RESISTANCES ARE IN OHMS, K INDICATES 1,000.
11. NM INDICATES NOT MEASURABLE.
12. NC INDICATES NO CONNECTION.
13. INF INDICATES INFINITE.

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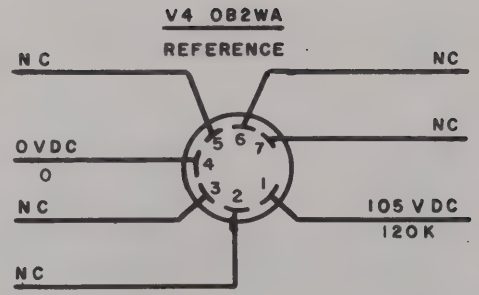
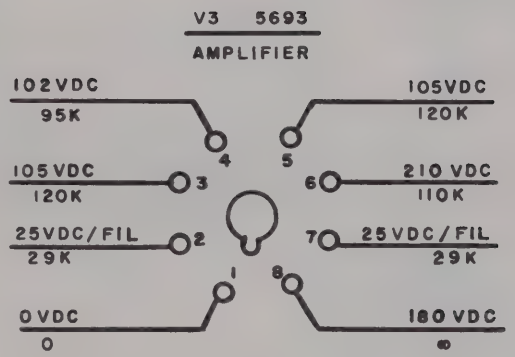
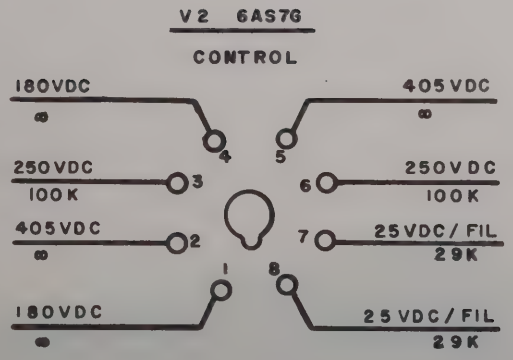
Figure 6-8. Radio Transmitter T-279/UR, v-r measurements.

NOTES:

1. ALL VOLTAGES AND RESISTANCES MEASURED WITH MULTIMETER, SIMPSON MODEL 260 FROM TERMINAL INDICATED TO CHASSIS GROUND.
2. NC INDICATES NO CONNECTION.
3. DASH (–) INDICATES NO MEASUREMENT SHOULD BE TAKEN.
4. FIL INDICATES FILAMENT TERMINALS ACROSS WHICH 6.3 VAC SHOULD BE MEASURED.
5. FIL.* INDICATES FILAMENT TERMINALS ACROSS WHICH 5.0 VAC SHOULD BE MEASURED.







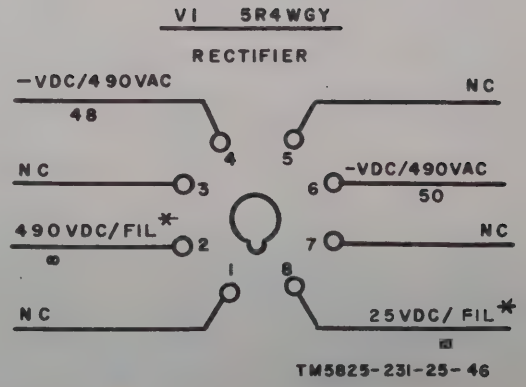
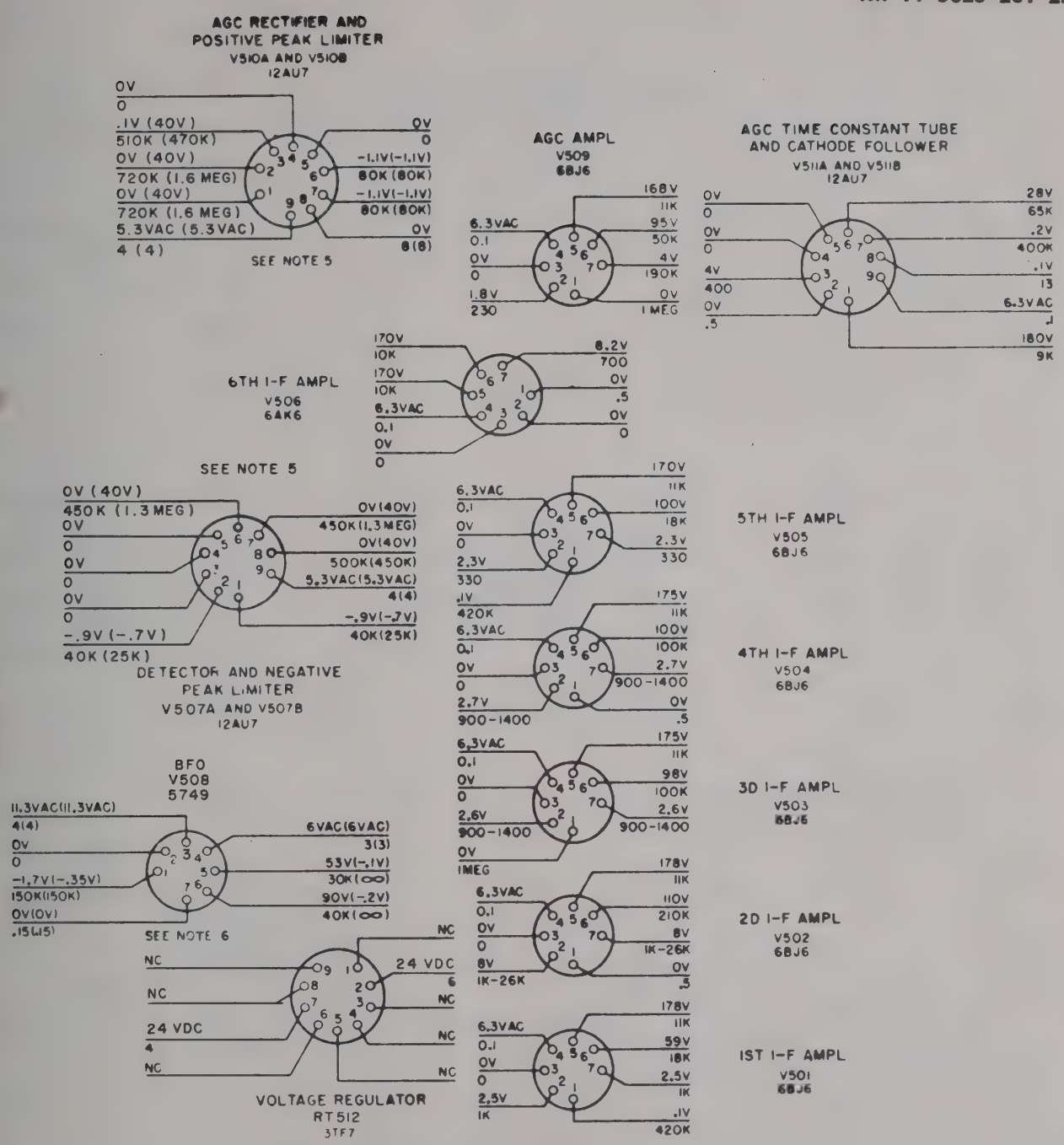


Figure 6–9. Power supply, RF detector, v–r measurements.



NOTES:

1. UNLESS OTHERWISE SHOWN,
   RESISTORS ARE IN OHMS AND ARE MEASURED FROM PIN SOCKET TO GROUND WITH A 20,000 OHMS-PER-VOLT METER (SUCH AS MULTIMETER TS-352/U).
   VOLTAGES ARE DC AND ARE MEASURED FROM PIN SOCKET TO GROUND WITH A VTVM (SUCH AS ELECTRONIC MULTIMETER TS-505/U).
   READINGS ARE THE SAME ON ALL BANDS.
2. NC INDICATES NO CONNECTION.
3. ∞ INDICATES INFINITY.
4. UNLESS OTHERWISE NOTED, SET CONTROLS AS FOLLOWS:
   SET S801 TO 115 VOLTS AC, [FUNCTION] TO [AGC], [AUDIO RESPONSE] TO [MED], [RF GAIN] TO [10], [LOCAL GAIN] TO [10], AND [BANDWIDTH] TO [8KC].
5. READINGS IN PARENTHESES ARE MADE WITH [LIMITER] AT [OFF]. OTHER READINGS ARE WITH [LIMITER] AT [10].
6. READINGS IN PARENTHESES ARE MADE WITH [BFO] AT [OFF].

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Figure 6-10. IF Subchassis, v-r measurements.

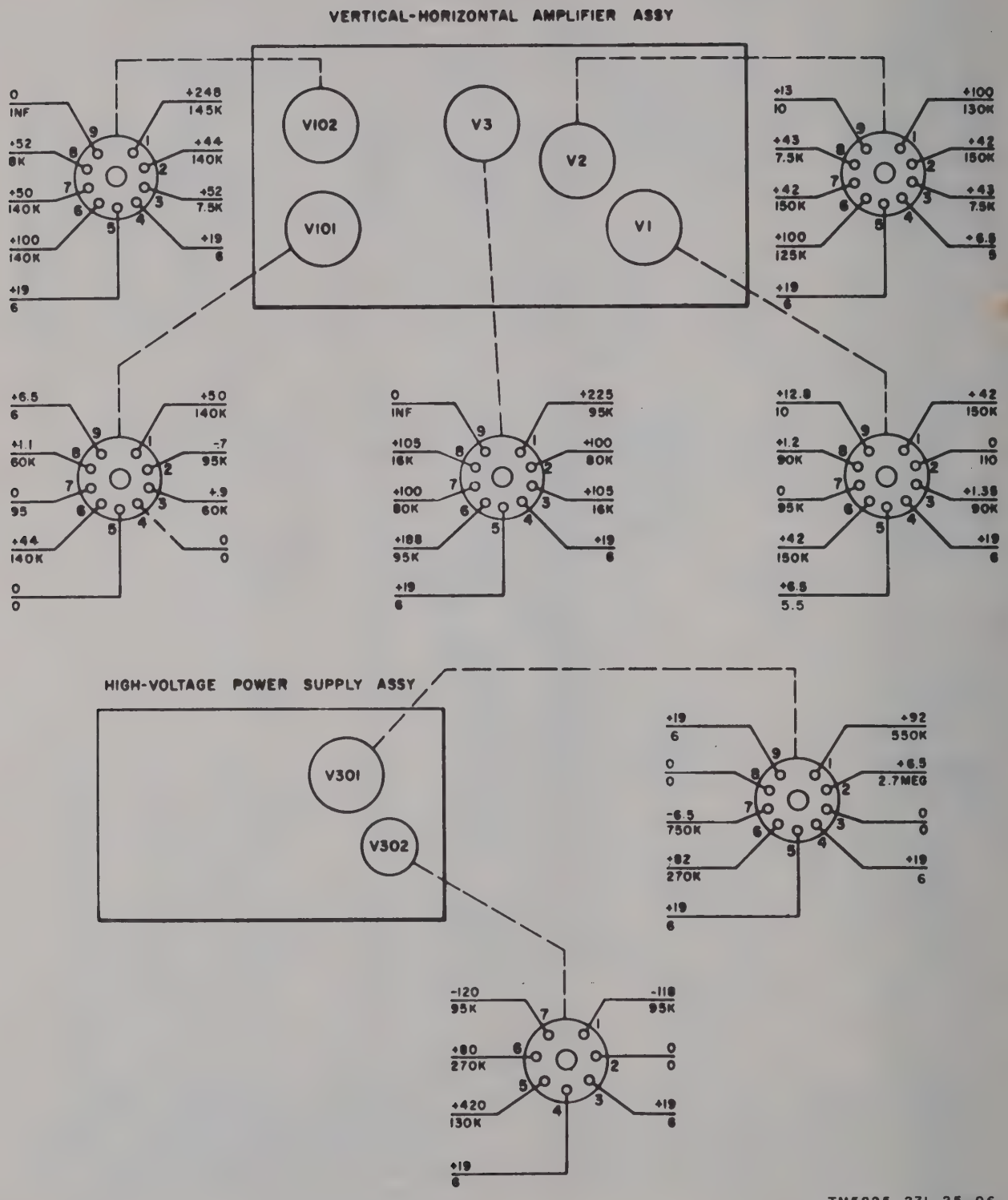

Figure 6–11. Vertical-horizontal amplifier oscilloscope assembly, v–r measurements.

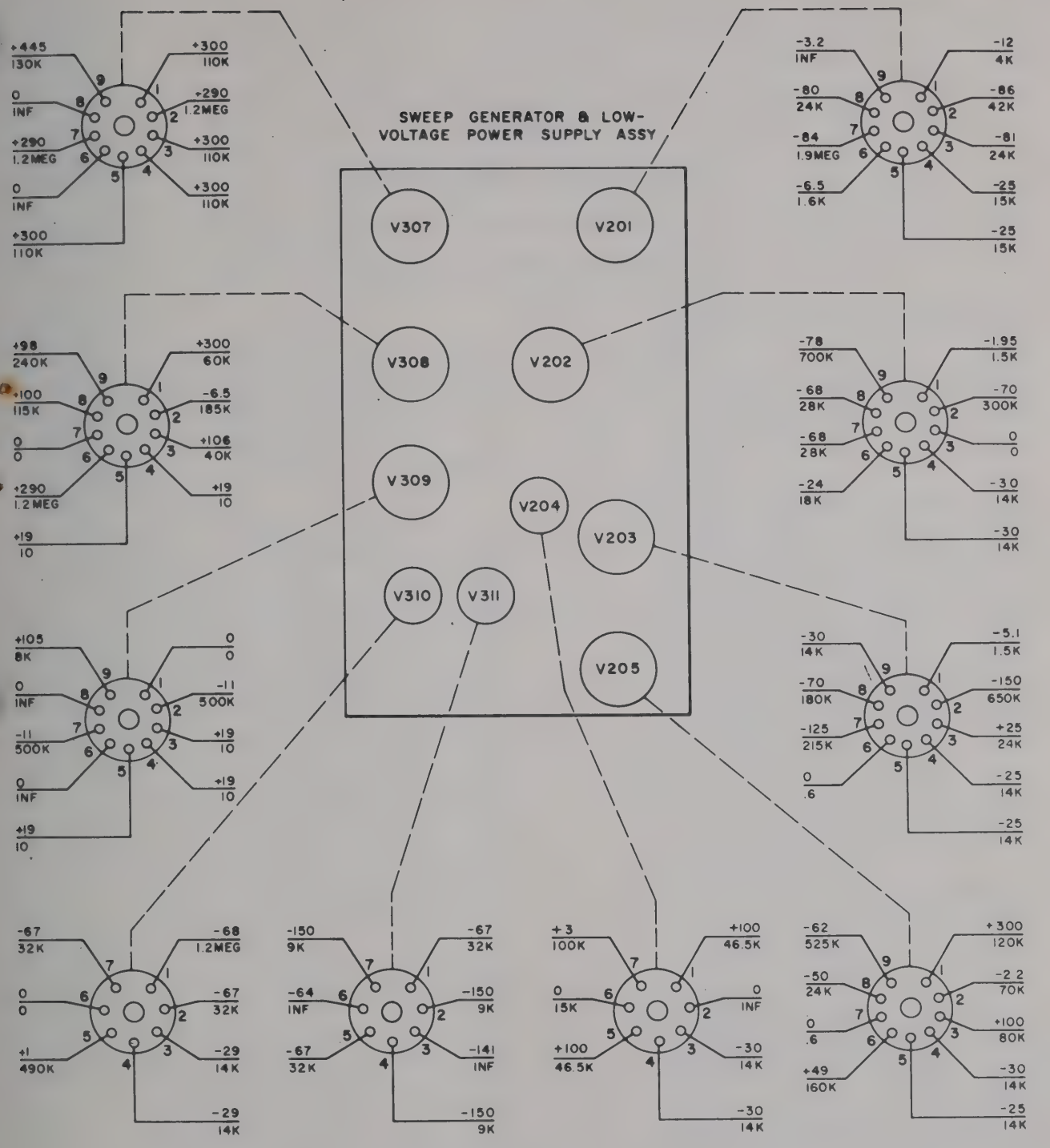

Figure 6–12. Sweep generator and low voltage oscilloscope, v–r measurements.

APPENDIX

MAINTENANCE ALLOCATION

Section I. INTRODUCTION

1. General

a. This appendix assigns maintenance functions to be performed on components, assemblies, and subassemblies by the lowest appropriate maintenance category.

b. Columns in the maintenance allocation chart are as follows:

(1) *Part or component.* This column shows only the nomenclature or standard item name. Additional descriptive data are included only where clarification is necessary to identify the component. Components, assemblies, and subassemblies are listed in top–down order, that is the assemblies which are part of a component are listed immediately below that component, and subassemblies which are part of an assembly are listed immediately below that assembly. Each generation breakdown (components, assemblies, or subassemblies) are listed in disassembly order or alphabetical order.

(2) *Maintenance function.* This column indicates the various maintenance functions allocated to the categories.

(*a*) *Service.* To clean, to preserve, and to replenish lubricants.

(*b*) Adjust To regulate periodically to prevent malfunction.

(*c*) Inspect. To verify serviceability and detect incipient electrical or mechanical failure by scrutiny.

(*d*) *Test.* To verify serviceability and to detect incipient electrical or mechanical failure by use of special equipment such as gages, meters, etc.

(*e*) *Replace.* To substitute serviceable components, assemblies, or subassemblies, for unserviceable components, assemblies, or subassemblies.

(*f*) *Repair.* To restore an item to serviceable condition through correction of a specific failure or unserviceable condition. This function includes but is not limited to welding, grinding, riveting, straightening, and replacement of parts other than the trial and error replacement of running spare type items such as fuses, lamps, or electron tubes.

(*g*) *Align.* To adjust two or more components of an electrical system so that their functions are properly synchronized.

(*h*) *Calibrate.* To determine, check, or rectify the graduation of an instrument, weapon, or wapons system, or components of a weapons system.

(*i*) *Overhaul.* To restore an item to *completely serviceable* condition as prescribed by serviceability standards. This is accomplished through employment of the technique of "Inspect and Repair Only as Necessary" (IROAN). Maximum utilization of diagnostic and test eqipment is combined with minimum disassembly of the item during the overhaul process.

(*j*) *Rebuild.* To restore an item to a standard as near as possible to original or new condition in appearance, performance, and life expectancy. This is accomplished through the maintenance technique of complete disassembly of the item, inspection of all parts or components, repair or replacement of worn or unserviceable elements using original manufacturing tolerances and/or specifications, and subsequent reassembly of the item.

(3) *Operator, organization, direct support, and depot.* The symbol X indicates the category responsible for performing that particular maintenance operation, but does not necessarily indicate that repair parts will be stocked at that level. Categories higher than those marked by X are authorized to perform the indicated operation.

(4) *Tools required.* This column indicates codes assigned to each individual tool equipment, test equipment, and maintenance equipment referenced. The grouping of codes in this column of the maintenance allocation chart indicates the tool, test, and maintenance equipment required to perform the maintenance function.

(5) *Remarks.* Entries in this column will be utilized when necessary to clarify any of the data cited in the preceding columns.

c. Columns in the allocation of tools for maintenance functions are as follows:

(1) *Tools required for maintenance functions.* This column lists tools, test, and maintenance equipment required to perform the maintenance functions.

(2) *Operator, organization, direct supporg, general support, and depot.* The dagger (†) symbol indicates the categories normally allocated the facility.

(3) *Tool code.* This column lists the tool code assigned.

A–2. Maintenance by Using Organizations

When this equipment is used by Signal services organizations organic to theater headquarters or communication zones to provide theater communications, those maintenance functions allocated up to and including general support are authorized to the organization operating this equipment.

Section II. MAINTENANCE ALLOCATION CHART

PART OR COMPONENT	MAINTENANCE FUNCTION	MAINTENANCE CATEGORY O/C	O	DS	GS	D	TOOLS REQUIRED	REMARKS
DIRECTION FINDER SET AN/TRD-15	service		X				15	
	adjust			X			13	
	inspect		X					
	test		X				5,12	External voltage continuity, electron tubes
				X			2,3,6,7,8,9,12,17	Test after troubleshooting and repair
					X		1,2,3,4,6,7,8,9,12, 16,17	Test and return to user stock
						X	1,2,3,4,6,7,8,9,10, 11,12,13,14,15,16,17	Test an return to depot stock
	repair			X			13	
					X		13,14	
	overhaul					X	13,14	
ADAPTOR, TRIPOD HEAD	replace		X					
ADAPTOR, TUBE SOCKET, 7 PIN MINIATURE	replace		X					
ADAPTOR UG-29/U	replace		X					
AMPLIFIER, ELECTRONIC CONTROL AM-3545/TRD	service		X					
	test			X			6,7,8	
	repair			X			13	
	overhaul					X	13,14	
FUSE, CARTRIDGE	replace		X				15	
LAMP, NEON	replace		X				15	
ANTENNA SET AN/TRA-32	repair			X			13	
ANTENNA ASSEMBLY AS-1882/GR	repair			X			13	
ANTENNA LOADING DISC MX-1168/GR	replace		X					
ANTENNA SECTION AT-442/GR	replace		X					
NETWORK, IMPEDANCE MATCHING	replace		X				13	
ANTENNA SECTION AT-443/GR	replace		X					
ANTENNA SECTION AT-444/GR	replace		X					
ANTENNA SECTION AT-445/GR	replace		X					
BAG, ANTENNA	replace		X					
BASE, ANTENNA MT-865/GR	replace		X					
PIN, LOCATING	replace		X					
COUNTERPOISE, ANTENNA MX-4487/G	replace			X				

PART OR COMPONENT	MAINTENANCE FUNCTION	MAINTENANCE CATEGORY O/C	O	DS	GS	D	TOOLS REQUIRED	REMARKS
AN/TRD-15 (Continued)								
CLAMP, STEEL, DWG SM-B-132344	replace		X					
BAG, COTTON DUCK	replace		X					
GUY MX-7219/G	replace		X					
STAKE, GROUND GP-2	replace		X					
STAKE GP-111/G	replace		X					
STRAP GROUND	replace		X					
ANTI-STATIC SOLUTION, 1 OZ	replace		X					
BAG, COTTON	replace		X					
BALL AND SOCKET	replace		X					
CABINET, ELECTRICAL EQUIPMENT CY-3704/TRD	repair				X		13	
CABLE ASSEMBLY CG-92G/U	repair			X			13	
CABLE ASSEMBLY CG-409B/U	repair			X			13	
CABLE ASSEMBLY CG-833A/U	repair			X			13	
CABLE ASSEMBLY CG-1079B/U	repair			X			13	
CABLE ASSEMBLY CG-3177/U	repair			X			13	
CABLE ASSEMBLY, RF; CG-3178/TRD-15	repair			X			13	
CABLE ASSEMBLY, PWR, ELECT; CX-2378/U	repair			X			13	
CABLE ASSEMBLY, PWR, ELECT; CX-11180/U	repair			X			13	
CABLE ASSEMBLY, PWR, ELECT; CX-11181	repair			X			13	
CABLE ASSEMBLY, PWR, ELECT; CX-11221/U	repair			X			13	
CABLE ASSEMBLY, PWR, ELECT; CX-11222/U	repair			X			13	
CABLE ASSEMBLY, PWR, ELECT; CX-11223/U	repair			X			13	
CABLE ASSEMBLY, PWR, ELECT; CX-11224/U	repair			X			13	
CABLE ASSEMBLY, PWR, ELECT; CX-11226/U	repair			X			13	
CABLE ASSEMBLY, PWR, ELECT; CX-11227/U	repair			X			13	
CABLE ASSEMBLY, PWR, ELECT; CX-11228/U	repair			X			13	

PART OR COMPONENT	MAINTENANCE FUNCTION	MAINTENANCE CATEGORY O/C	O	DS	GS	D	TOOLS REQUIRED	REMARKS
AN/TRD-15 (Continued)								
CABLE ASSEMBLY, PWR, ELECT; CX-11229/U	repair			X			13	
COMPASS, MAGNETIC, SURVEYOR'S	repair					X	13,14	
DETECTOR, RF; RF-159/TRD-15	test		X				5,12	Voltage measurements, electron tubes
				X			2,3,6,7,8,12,17	
						X	2,3,6,7,8,11,17	
	repair			X			13	
	overhaul					X	13,14	
ELECTRON TUBE	replace		X				15	
FISE	replace		X				15	
DRIVE, GONIOMETER-ROTARY COUPLER TG-126/TRD-15	repair			X			13	
BELT, POSITIVE DRIVE	replace			X			13	
COUPLER, ROTARY, RF; CU-1096/TRD-15	repair					X	13,14	
GONIOMETER, ELECTRICAL GO-42/TRD-15	repair				X		13	
HAMMER, HAND 8 LBS	replace		X					
HEADSET H-133/U	repair				X		13	
INDICATOR, AZIMUTH; IP-669/TRD-15	test		X				5,12	Electron tubes, external voltages
				X			3,6,7,8,12	
	repair			X			13	
	overhaul					X	13,14	
ADAPTER, HOOD	replace		X				15	
CRYSTAL, QUARTZ	replace		X				15	
ELECTRON TUBE	replace		X				15	
ELECTRON TUBE, CATHODE RAY	replace		X				15	
FUSE	replace		X				15	
HANDLE	replace		X				15	
HOOD, VIEWING	replace		X					
KNOB	replace		X				15	
LAMP, INCANDESCENT	replace		X				15	

PART OR COMPONENT	MAINTENANCE FUNCTION	MAINTENANCE CATEGORY O/C	O	DS	GS	D	TOOLS REQUIRED	REMARKS
AN/TRD-15 (Continued)								
OSCILLOSCOPE, HEWLETT PACKARD 120B/AR	service		X				15	
	adjust			X			13	
	test			X			3,4,6,7,8,12	Test after repair
					X		3,4,6,7,8,12,16	Test and return to user stock
						X	3,4,6,7,8,11,16	Test and return to depot stock
	repair			X			13	
	overhaul					X	13,14	
ADAPTER, HOOD	replace		X				15	
ELECTRON TUBE	replace		X				15	
ELECTRON TUBE, CATHODE RAY	replace		X				15	
FUSE	replace		X				15	
HOOD	replace		X					
KNOB	replace		X				15	
PANEL, POWER DISTRIBUTION SB-1747/TRD-15	repair			X			13	
	overhaul					X	13,14	
PLUMB BOB	replace		X					
POWER SUPPLY PP-4482/TRD	test		X				5	
				X			6,7,17	
	repair			X			13	
	overhaul					X	13,15	
RECEIVER, RADIO R-725/URR	service		X				15	
	adjust			X			15	
	inspect		X				15	
	test		X				5,12	External voltage, electron tubes
				X			2,3,6,7,8,9,12,17	Test after repair
					X		1,2,3,6,7,8,9,12,17	Test and return to user stock
						X	1,2,3,6,7,8,9,11,17	Test and return to depot stock
	repair			X			13	
	overhaul					X	13,14	
ELECTRON TUBE	replace		X				15	
FUSE	replace		X				15	
KNOB	replace		X				15	
LAMP, GLOW	replace		X				15	
LAMP, INCANDESCENT	replace		X				15	
ROD, LEVEL	replace		X					

PART OR COMPONENT	MAINTENANCE FUNCTION	MAINTENANCE CATEGORY O/C	O	DS	GS	D	TOOLS REQUIRED	REMARKS
AN/TRD-15 (Continued)								
TAPE, MEASURING, STEEL, 300FT	replace		X					
TRANSMITTER, RADIO T-279/UR	test		X				5,12	Battery voltage, electron tubes
				X			2,3,6,7,8,12	Test after repair
					X		2,3,6,7,8,12	Test and return to user stock
						X	2,3,6,7,8,17	Test and return to depot stock
	repair			X			13	
	overhaul					X	13,14	
ANTENNA	replace		X					
BATTERY BA-404/U	replace		X					
BATTERY BA-424/U	replace		X					
ELECTRON TUBE	replace		X					
KNOB	replace		X				15	
LAMP, NEON	replace		X				15	
TRIPOD	repair					X	13,14	

Section III. ALLOCATION OF TOOLS FOR MAINTENANCE FUNCTIONS

TOOLS REQUIRED FOR MAINTENANCE FUNCTIONS	MAINTENANCE CATEGORY O/C	O	DS	GS	D	TOOL CODE	REMARKS
AN/TRD-15 (Continued)							
ANALYZER SPECTRUM TS-723/U				†	†	1	
FREQUENCY METER AN/USM-159			†	†	†	2	
GENERATOR, SIGNAL SG-71/FCC			†	†	†	3	
GENERATOR, SIGNAL SG-299/U			†	†	†	4	
MULTIMETER AN/URM-105		†				5	
MULTIMETER ME-26/U			†	†	†	6	
MULTIMETER TS-352/U			†	†	†	7	
OSCILLOSCOPE OS-46/U			†	†	†	8	
R.F. SIGNAL GENERATOR AN/URM-25			†	†	†	9	
SIMULATOR, ANTENNA					†	10	
TEST SET, ELECTRON TUBE TV-2/U					†	11	
TEST SET, ELECTRON TUBE TV-7/U		†	†	†		12	
TOOL KIT, RADAR & RADIO REPAIRMAN TK-87/U			†	†	†	13	
TOOL KIT, SUPPLEMENTARY RADAR & RADIO REPAIR TK-88/U					†	14	
TOOL KIT, RADIO REPAIR TK-115/G		†				15	
TRANSFORMER, VAR. PWR CN-16/U				†	†	16	
VOLTMETER ME-30/U			†	†	†	17	

By Order of the Secretary of the Army:

HAROLD K. JOHNSON,
General, United States Army,
Chief of Staff.

Official:

J. C. LAMBERT,
Major General, United States Army,
The Adjutant General.

Distribution:

Active Army:

USASA (2)
CNGB (1)
CC–E (7)
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USACDCCBRA (1)
USACDCCEA (1)
USACDCOA (1)
USACDCQMA (1)
USACDCTA (1)
USACDCADA (1)
USACDCARMA (1)
USACDCAVNA (1)
USACDCARTYA (1)
USACDCSWA (1)
USACDCCEA:
  Ft Huachuca (1)
USACDCEC (10)
USCONARC (5)
USAMC (5)
ARADCOM (5)
ARADCOM Rgn (2)
OS Maj Comd (4)
LOGCOMD (2) except
  First (10)
  Ninth (10)
USAECOM (30)
USAMICOM (4)
USASMC (2)
USASCC (4)
MDW (1)
Armies (2)
Corps (2)
USAC (3)
11th Air Aslt Div (3)
4th USASA Fld Sta (5)
12th USASA Fld Sta (5)
14th USASA Fld Sta (5)
USMA (2)
Svc Colleges (2)
Br Svc Sch (2) except
  USASA Tng Cen & Sch (25)
USASPTCP (11)
USATC (2)
WRAMC (1)
Army Pic Cen (2)
Instl (2) except
  Ft Monmouth (70)
  Ft Hancock (4)
  Ft Gordon (10)
  Ft Huachuca (10)
  Ft Knox (12)
  Ft Carson (25)
WSMR (5)
GENDEP (2)
Sig Sec GENDEP (5)
Sig Dep (12)
A Dep (2) except
  LBAD (14)
  SAAD (30)
  TOAD (14)
  FTWOAD (10)
  LEAD (7)
  SHAD (3)
  NAAD (5)
  SVAD (5)
  CHAD (3)
  ATAD (10)
USACRREL (2)
USAERDAA (2)
USAERDAW (13)
Sig Fld Maint Shops (2)
Units org under fol TOE:
  (2 copies each)
  11–57
  11–97
  11–98
  11–117
  11–127
  11–155
  11–157
  11–158
  11–500 (AA–AC)
  11–587
  11–592
  11–597

NG: State AG (3).
USAR: None.
For explanation of abbreviations used, see AR 320–50.

☆ U. S. GOVERNMENT PRINTING OFFICE: 1966—204447/250

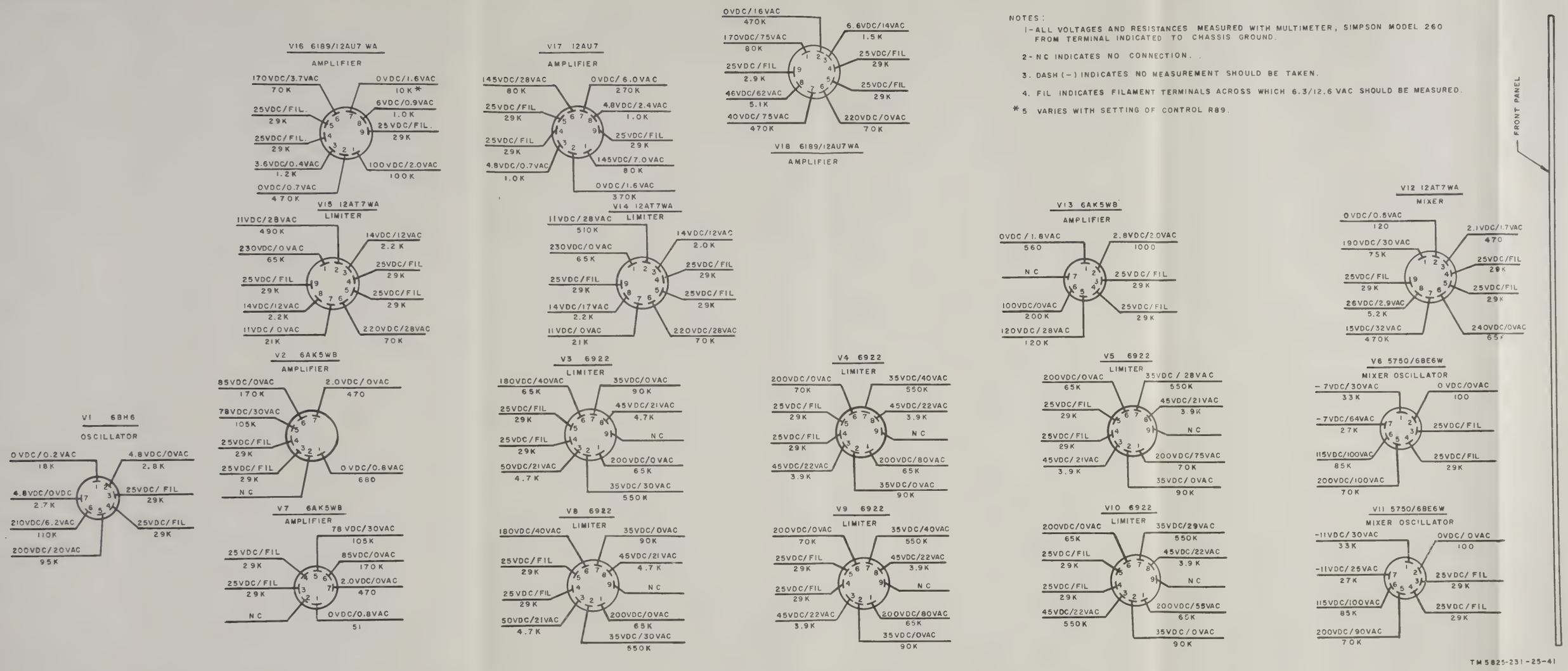
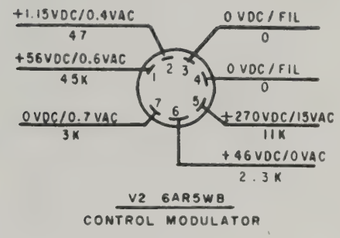
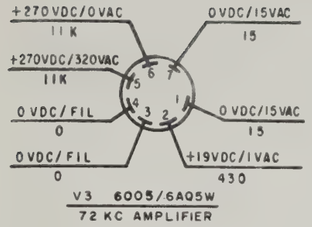
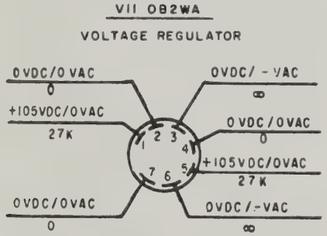
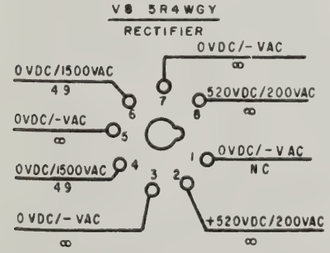


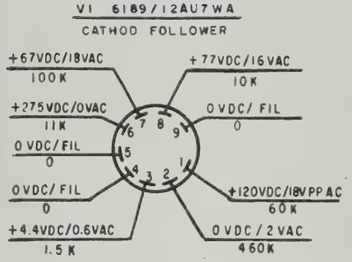
Figure 6-13. RF Detector, v-r measurements.

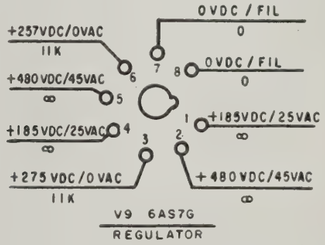


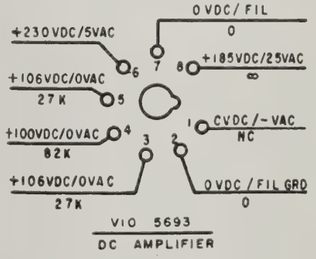


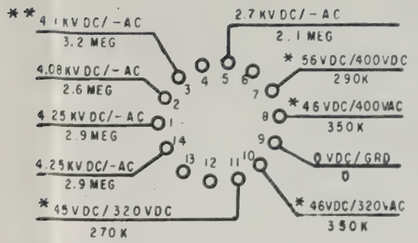






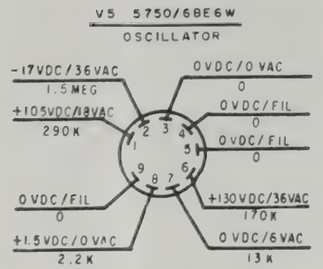


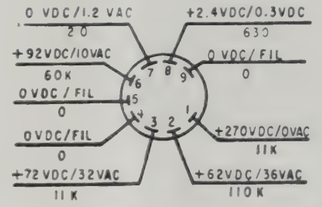


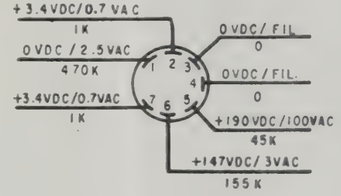


NOTES:

1. ALL VOLTAGES AND RESISTANCES MEASURED WITH MULTIMETER, SIMPSOM MODEL 260 FROM TERMINAL INDICATED TO CHASIS GROUND.
2. NC INDICATES NO CONNECTION.
3. DASH(—) INDICATES NO MEASURMENT SHOULD BE TAKEN.
4. FIL INDICATES FILAMENT TERMINALS ACROSS WHICH 6.3 VAC SHOULD BE MEASURED.
5. * VARIES WITH CENTERING CONTROL
6. ** VARIES WITH INTENSITY.

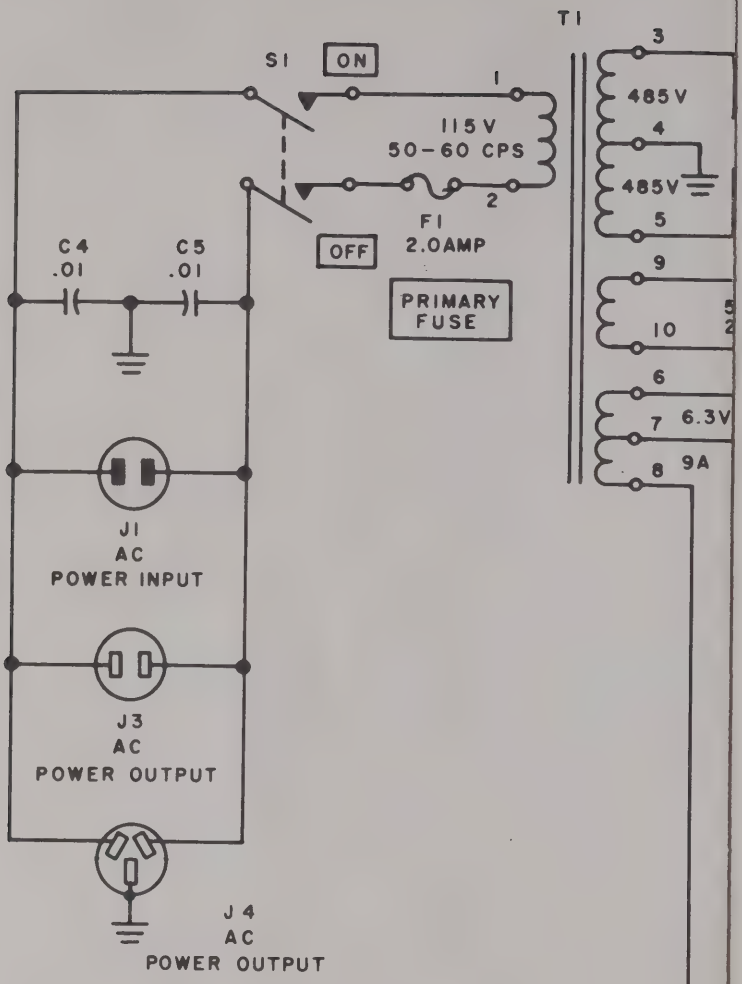






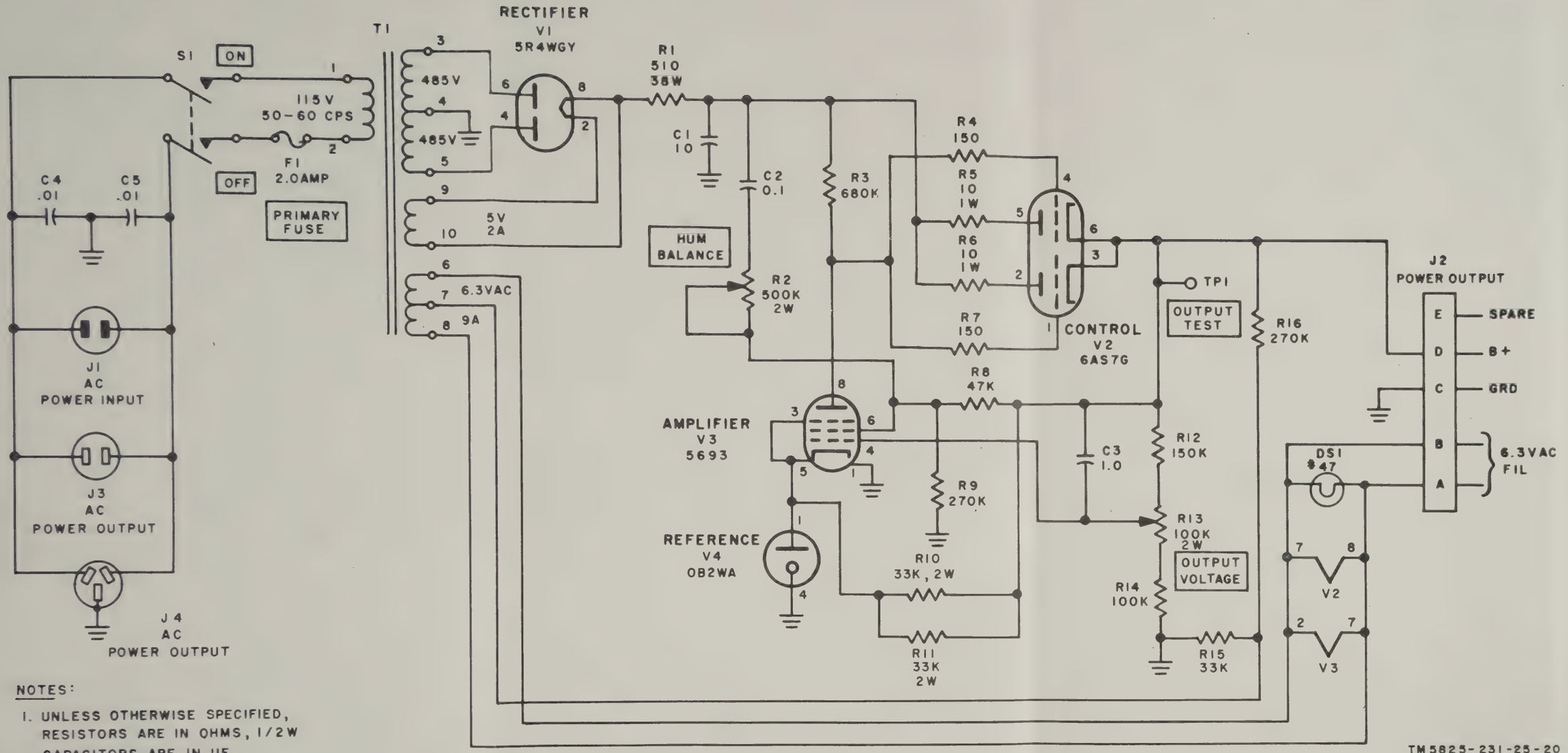
FRONT PANEL

Figure 6-14. Azimuth indicator, v-r measurements.



NOTES:

1. UNLESS OTHERWISE SPECIFIED, RESISTORS ARE IN OHMS, 1/2W CAPACITORS ARE IN UF



NOTES:

1. UNLESS OTHERWISE SPECIFIED, RESISTORS ARE IN OHMS, 1/2W CAPACITORS ARE IN UF

Figure 6–15. Power supply, RF detector, schematic diagram.

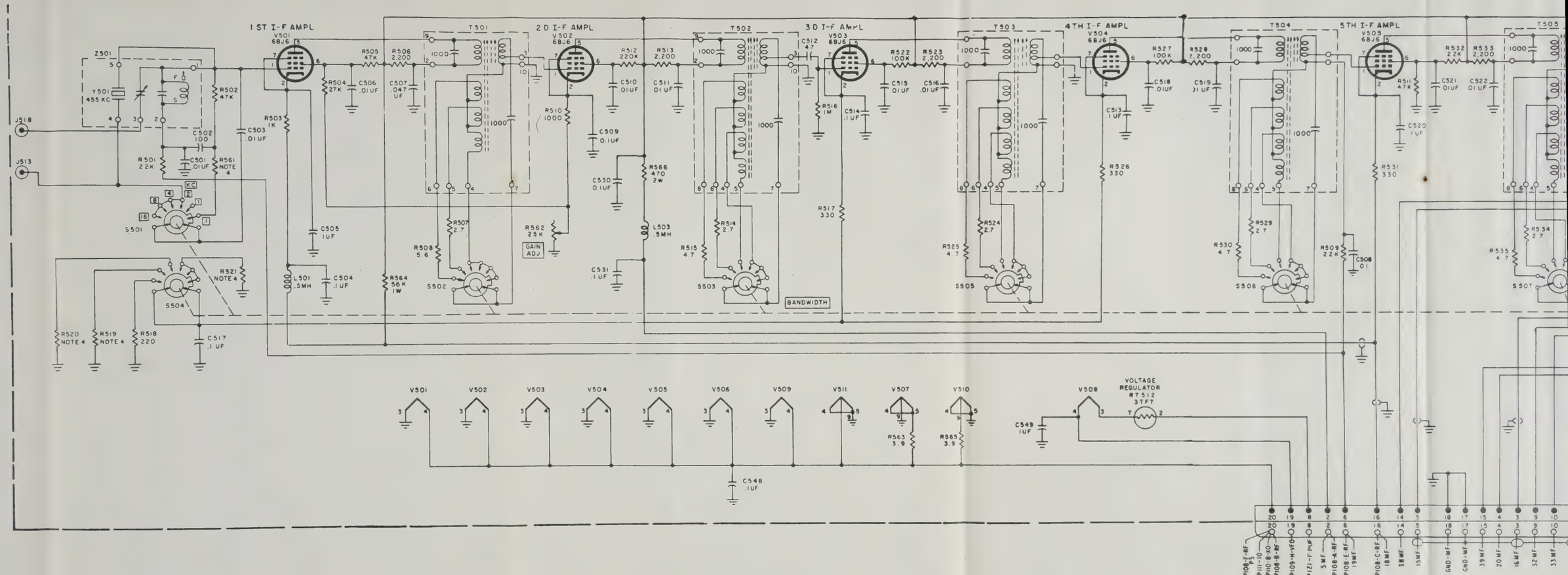


Figure 6–16. IF subchassis, schematic diagram.

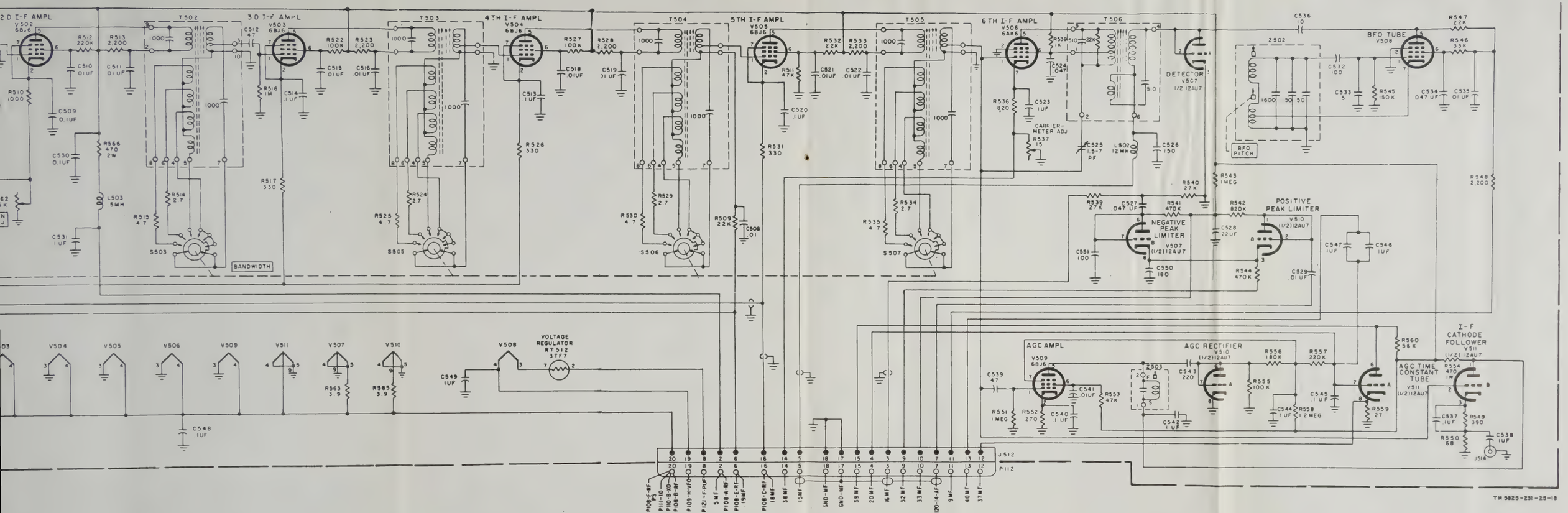
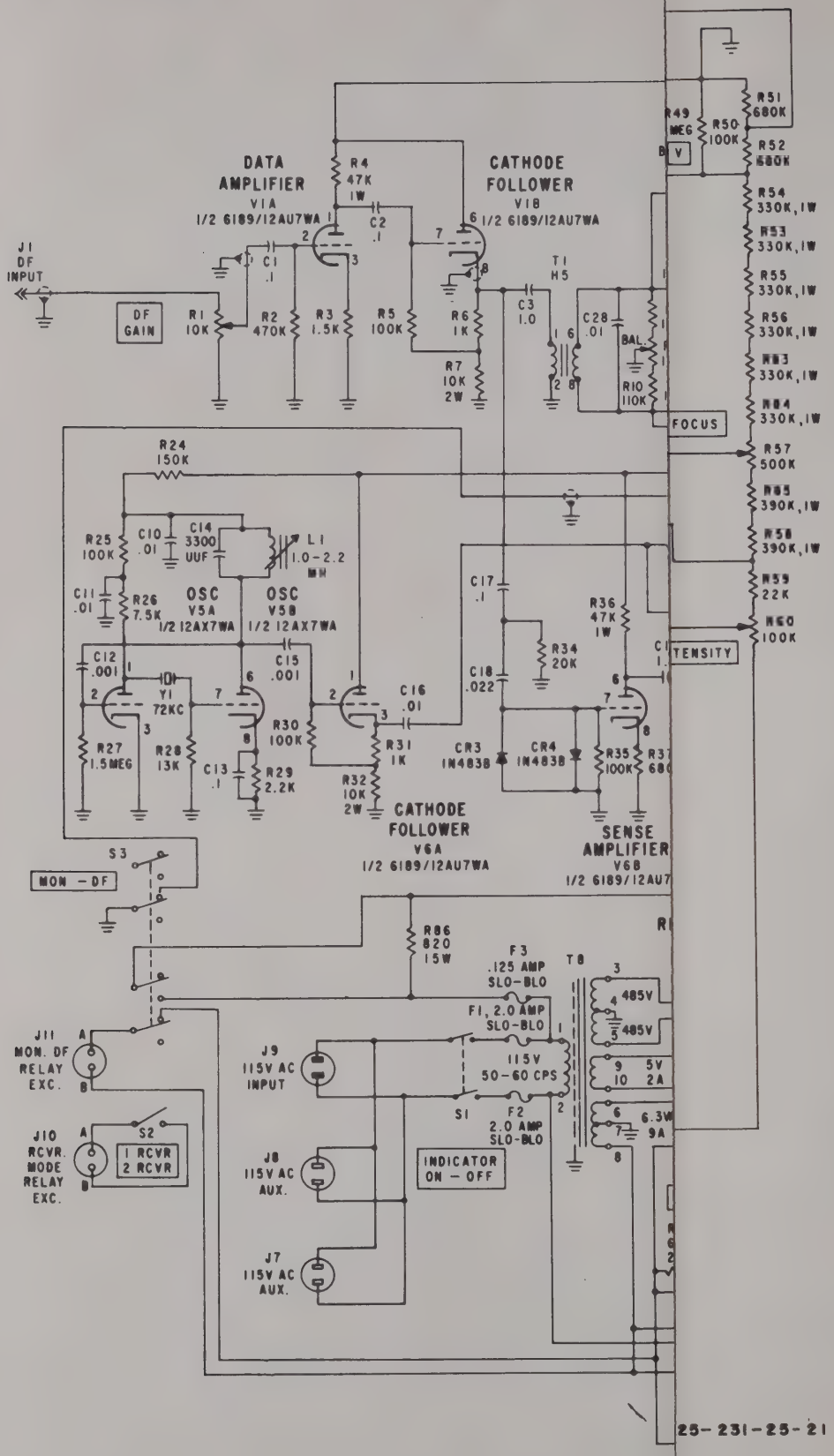
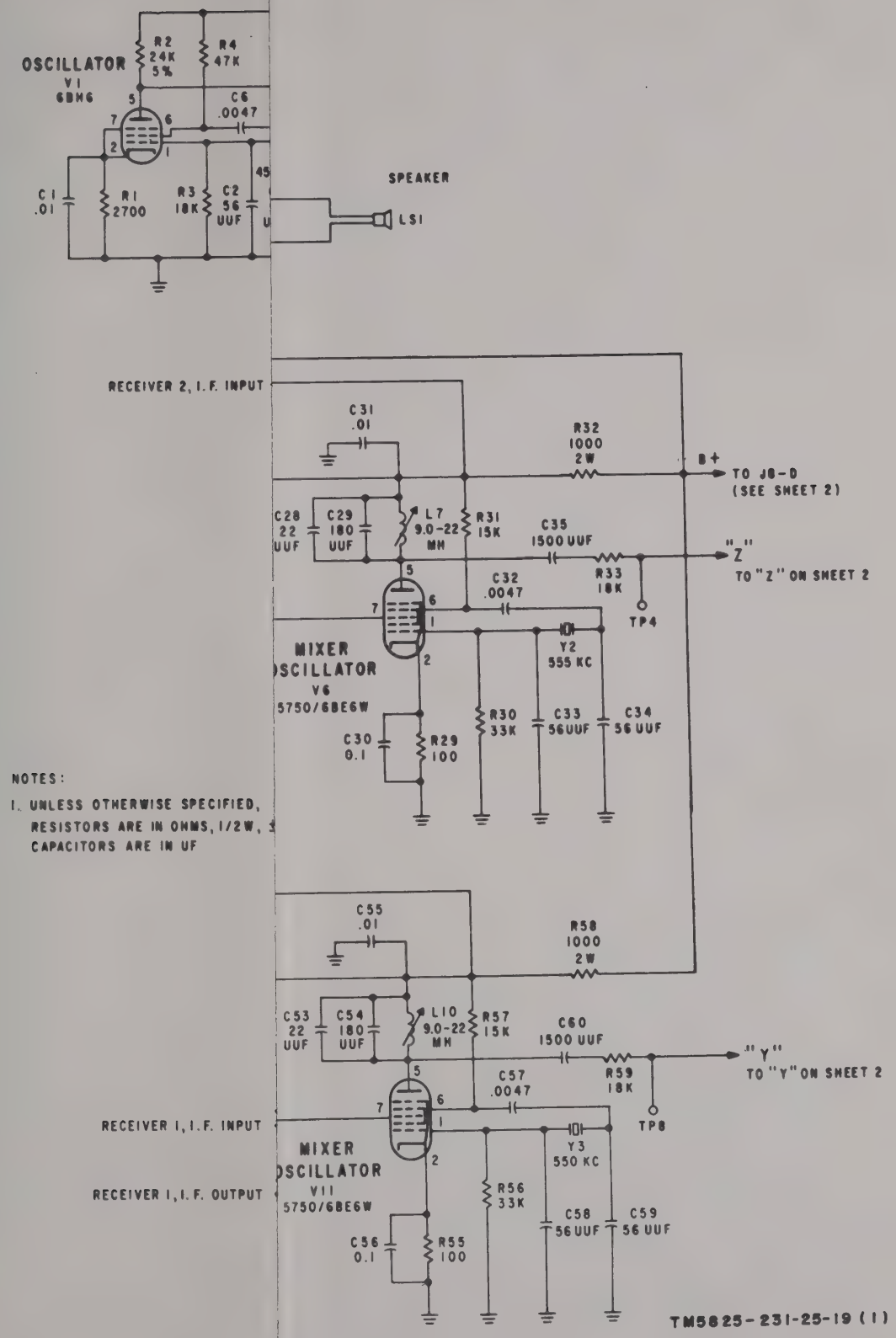


Figure 6-16. IF subchassis, schematic diagram.


DATA AMPLIFIER
V1A
1/2 6189/12AU7WA
CATHODE FOLLOWER
V1B
1/2 6189/12AU7WA
J1 DF INPUT
DF GAIN
R1 10K
R2 470K
R3 1.5K
R4 47K 1W
R5 100K
R6 1K
R7 10K 2W
C1 .1
C2 .1
C3 1.0
T1 H5
C28 .01
BAL.
R10 110K
FOCUS
R49 MEG
R50 100K
R51 680K
R52 680K
R54 330K, 1W
R53 330K, 1W
R55 330K, 1W
R56 330K, 1W
R83 330K, 1W
R84 330K, 1W
R57 500K
R85 390K, 1W
R58 390K, 1W
R59 22K
R60 100K
INTENSITY
R24 150K
R25 100K
C10 .01
C14 3300 UUF
L1 1.0-2.2 MH
C11 .01
R26 7.5K
OSC V5A 1/2 12AX7WA
OSC V5B 1/2 12AX7WA
C12 .001
C15 .001
Y1 72KC
R27 1.5MEG
R28 13K
C13 .1
R29 2.2K
R30 100K
R31 1K
R32 10K 2W
C16 .01
C17 .1
C18 .022
R34 20K
R36 47K 1W
CR3 IN483B
CR4 IN483B
R35 100K
CATHODE FOLLOWER
V6A
1/2 6189/12AU7WA
SENSE AMPLIFIER
V6B
1/2 6189/12AU7
S3
MON - DF
R86 820 15W
F3 .125 AMP SLO-BLO
F1, 2.0 AMP SLO-BLO
T8
485V
485V
5V 2A
6.3W 9A
J11 MON. DF RELAY EXC.
J10 RCVR. MODE RELAY EXC.
S2
1 RCVR
2 RCVR
J9 115V AC INPUT
115V 50-60 CPS
S1
F2 2.0 AMP SLO-BLO
J8 115V AC AUX.
J7 115V AC AUX.
INDICATOR ON - OFF
25-231-25-21


OSCILLATOR
V1
6BH6
R2
24K
5%
R4
47K
C6
.0047
C1
.01
R1
2700
R3
18K
C2
56
UUF
SPEAKER
LS1
RECEIVER 2, I.F. INPUT
C31
.01
R32
1000
2W
B+
TO J8-D
(SEE SHEET 2)
C28
22
UUF
C29
180
UUF
L7
9.0-22
MH
R31
15K
C35
1500 UUF
"Z"
TO "Z" ON SHEET 2
C32
.0047
R33
18K
TP4
MIXER
OSCILLATOR
V6
5750/6BE6W
Y2
555 KC
C30
0.1
R29
100
R30
33K
C33
56UUF
C34
56 UUF
NOTES:
1. UNLESS OTHERWISE SPECIFIED,
RESISTORS ARE IN OHMS, 1/2W,
CAPACITORS ARE IN UF
C55
.01
R58
1000
2W
C53
22
UUF
C54
180
UUF
L10
9.0-22
MH
R57
15K
C60
1500 UUF
"Y"
TO "Y" ON SHEET 2
C57
.0047
R59
18K
TP8
RECEIVER 1, I.F. INPUT
RECEIVER 1, I.F. OUTPUT
MIXER
OSCILLATOR
V11
5750/6BE6W
Y3
550 KC
R56
33K
C58
56 UUF
C59
56 UUF
C56
0.1
R55
100
TM5825-231-25-19 (1)

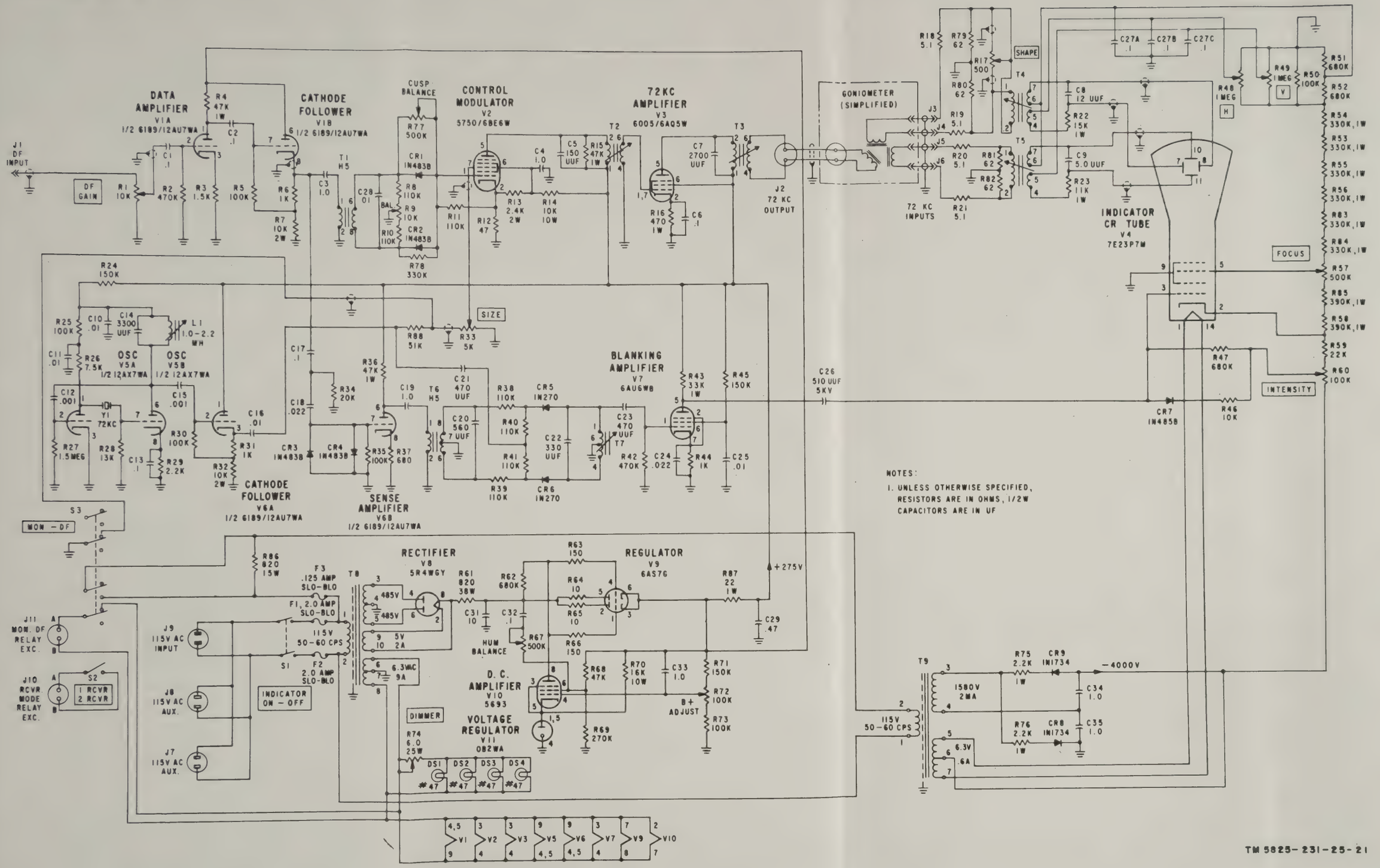


Figure 6-17. Azimuth indicator, schematic diagram.

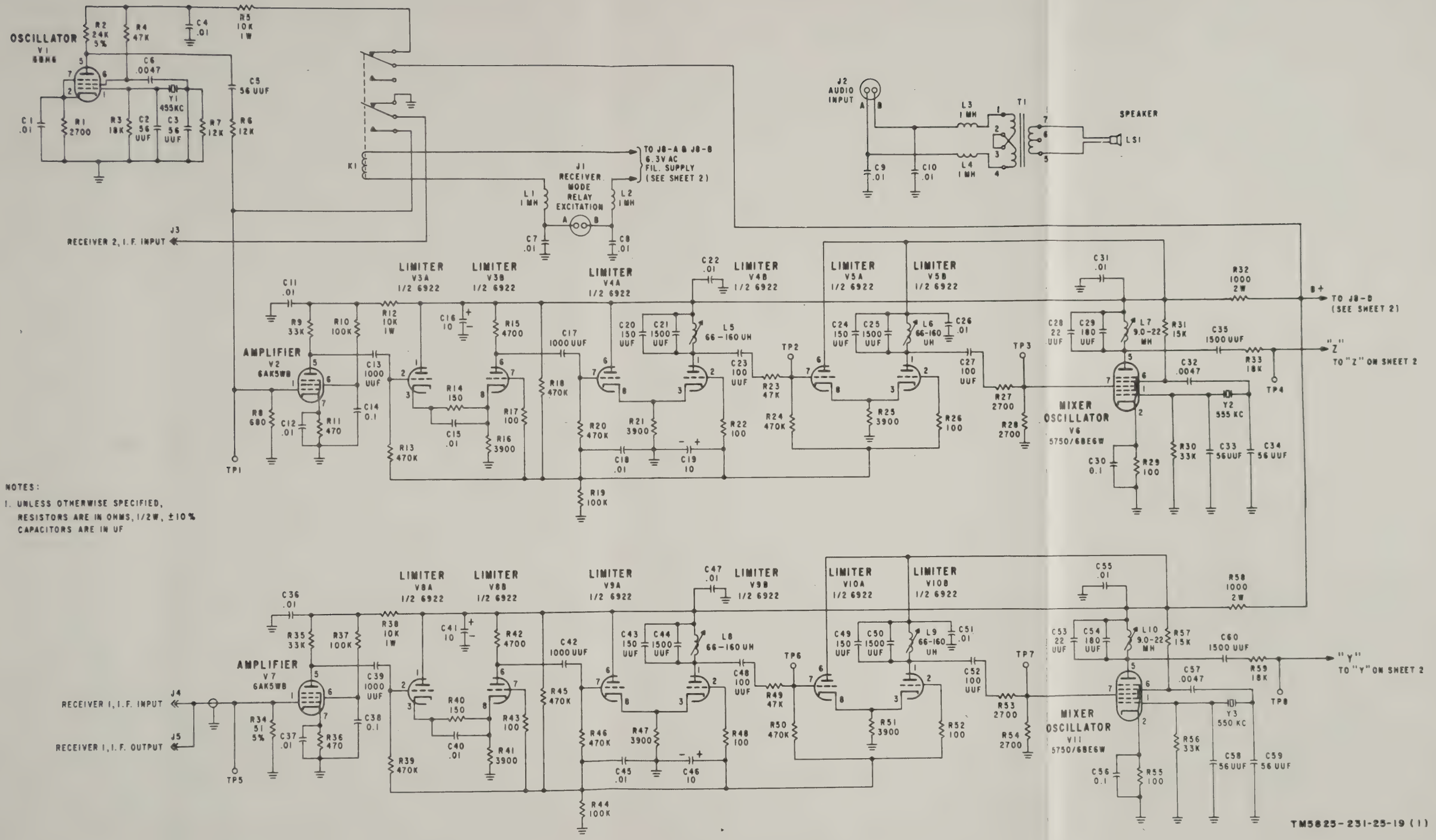
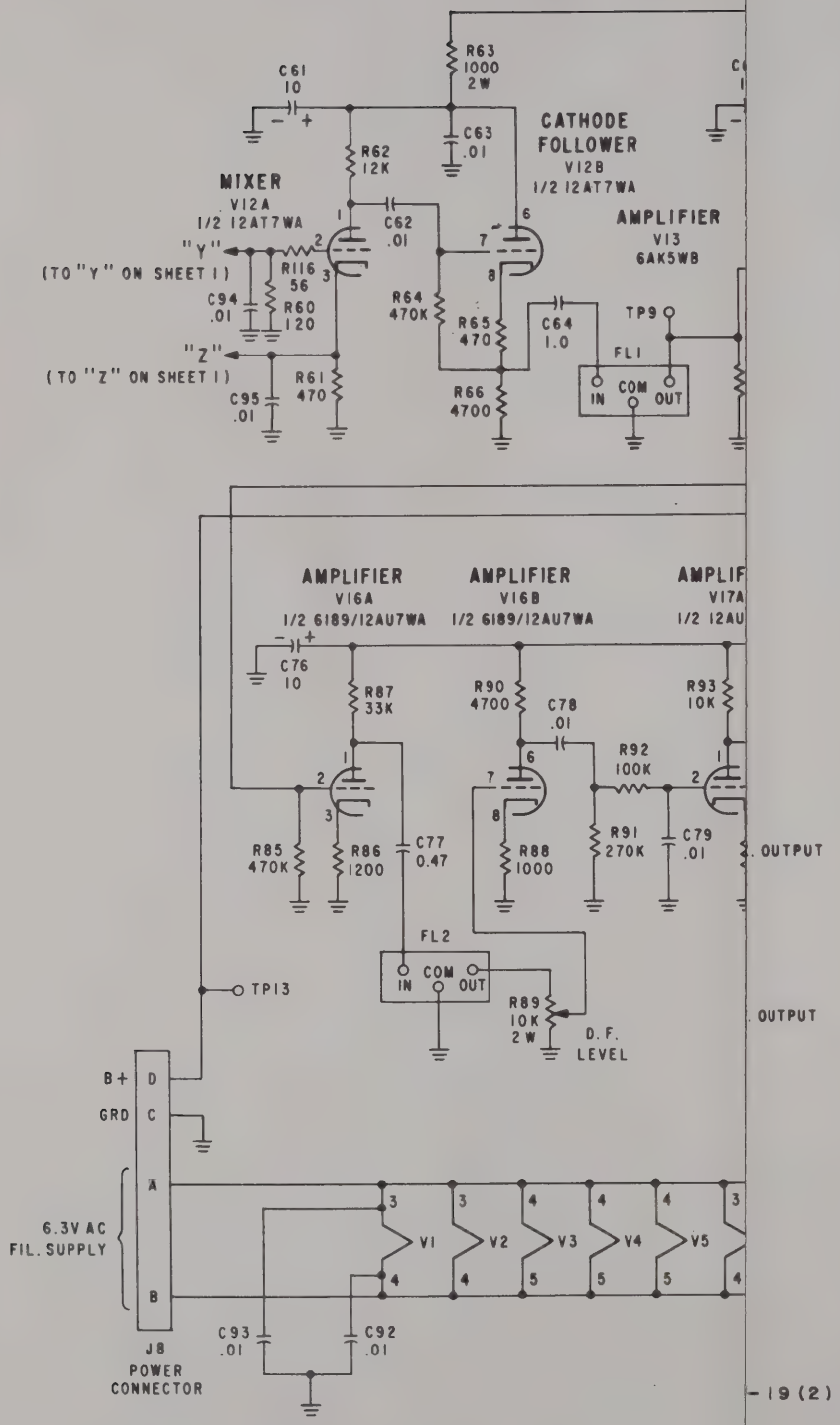
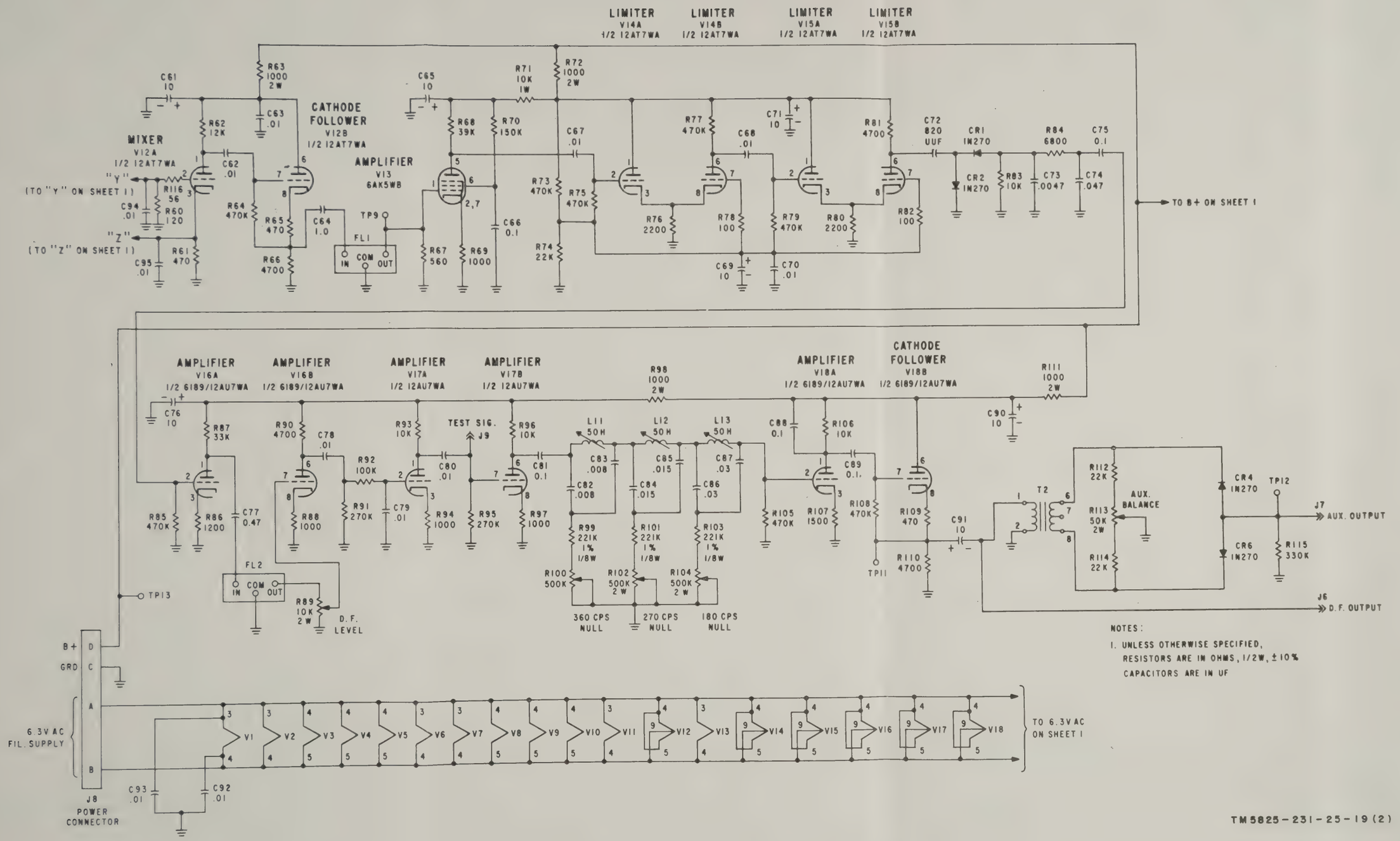


Figure 6–18 (1). RF detector, schematic diagram.


C61
10
R63
1000
2W
C63
.01
R62
12K
CATHODE
FOLLOWER
V12B
1/2 12AT7WA
MIXER
V12A
1/2 12AT7WA
C62
.01
AMPLIFIER
V13
6AK5WB
"Y"
(TO "Y" ON SHEET 1)
R116
56
C94
.01
R60
120
R64
470K
R65
470
C64
1.0
TP9
FL1
IN COM OUT
"Z"
(TO "Z" ON SHEET 1)
R61
470
C95
.01
R66
4700
AMPLIFIER
V16A
1/2 6189/12AU7WA
AMPLIFIER
V16B
1/2 6189/12AU7WA
C76
10
R87
33K
R90
4700
C78
.01
R93
10K
R92
100K
R85
470K
R86
1200
C77
0.47
R88
1000
R91
270K
C79
.01
OUTPUT
FL2
IN COM OUT
TP13
R89
10K
2W
D.F.
LEVEL
OUTPUT
B+ D
GRD C
A
B
6.3V AC
FIL. SUPPLY
V1
V2
V3
V4
V5
C93
.01
C92
.01
J8
POWER
CONNECTOR
19(2)



NOTES:

1. UNLESS OTHERWISE SPECIFIED, RESISTORS ARE IN OHMS, 1/2W, ±10% CAPACITORS ARE IN UF

TM5825-231-25-19(2)

Figure 6-18 (2). RF detector, schematic diagram.

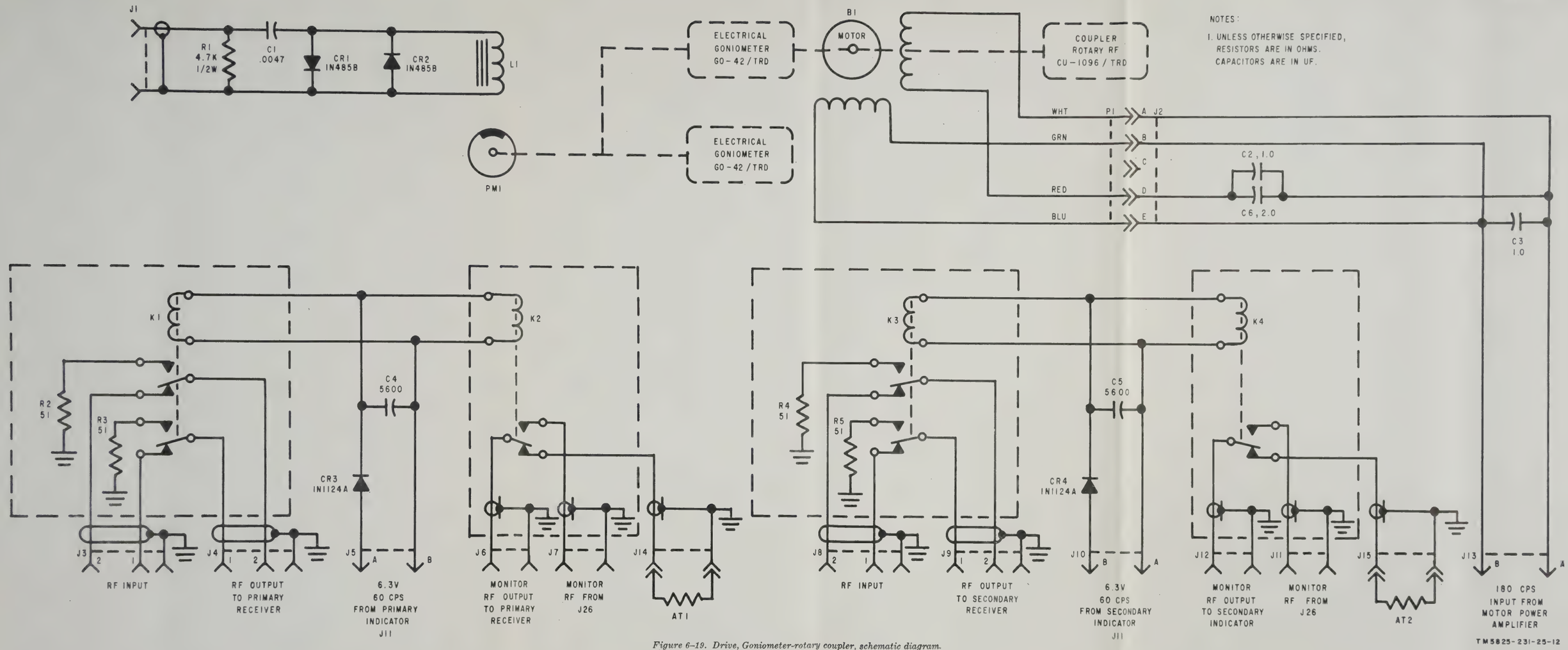


Figure 6-19. Drive, Goniometer-rotary coupler, schematic diagram.

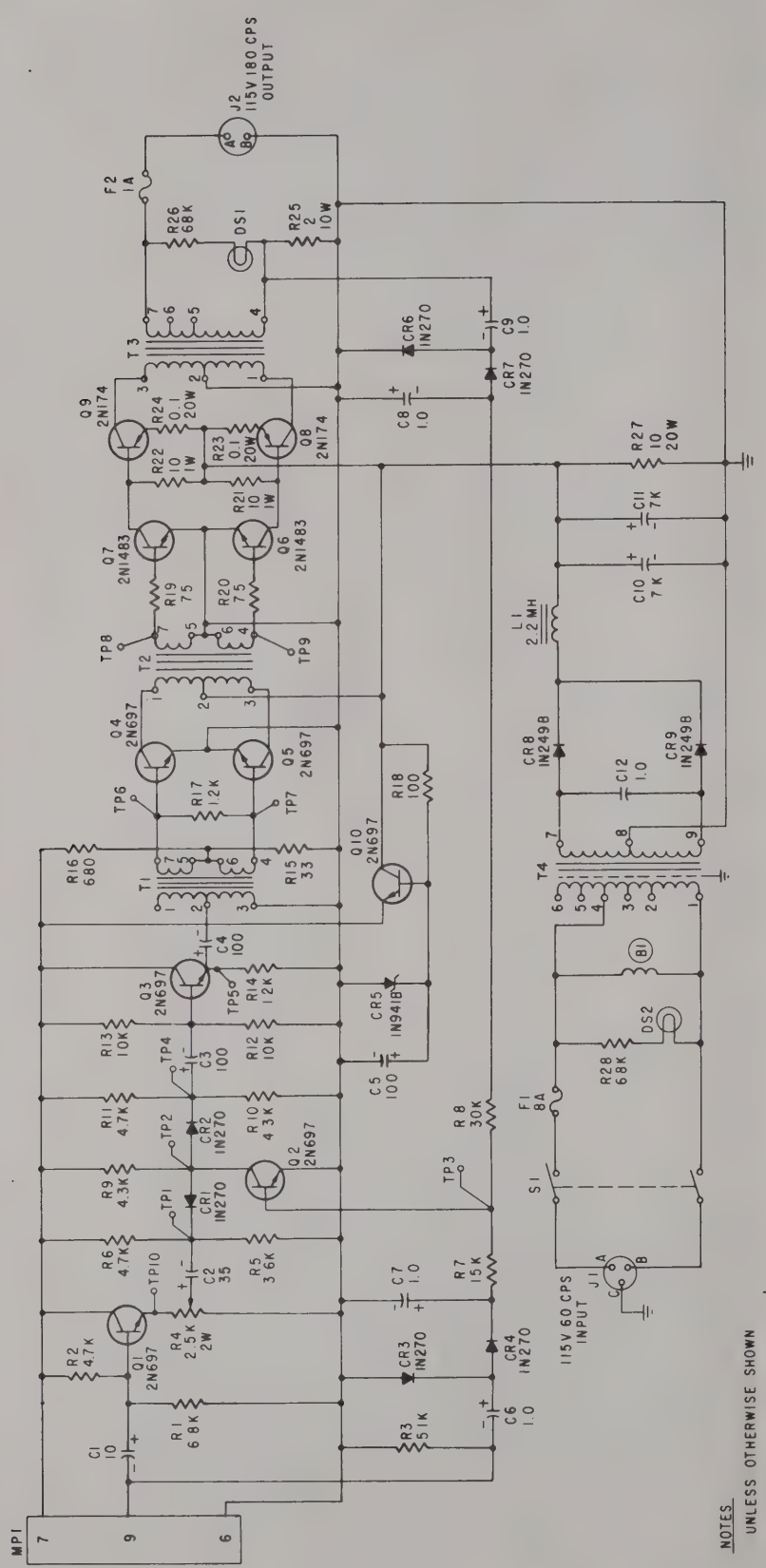
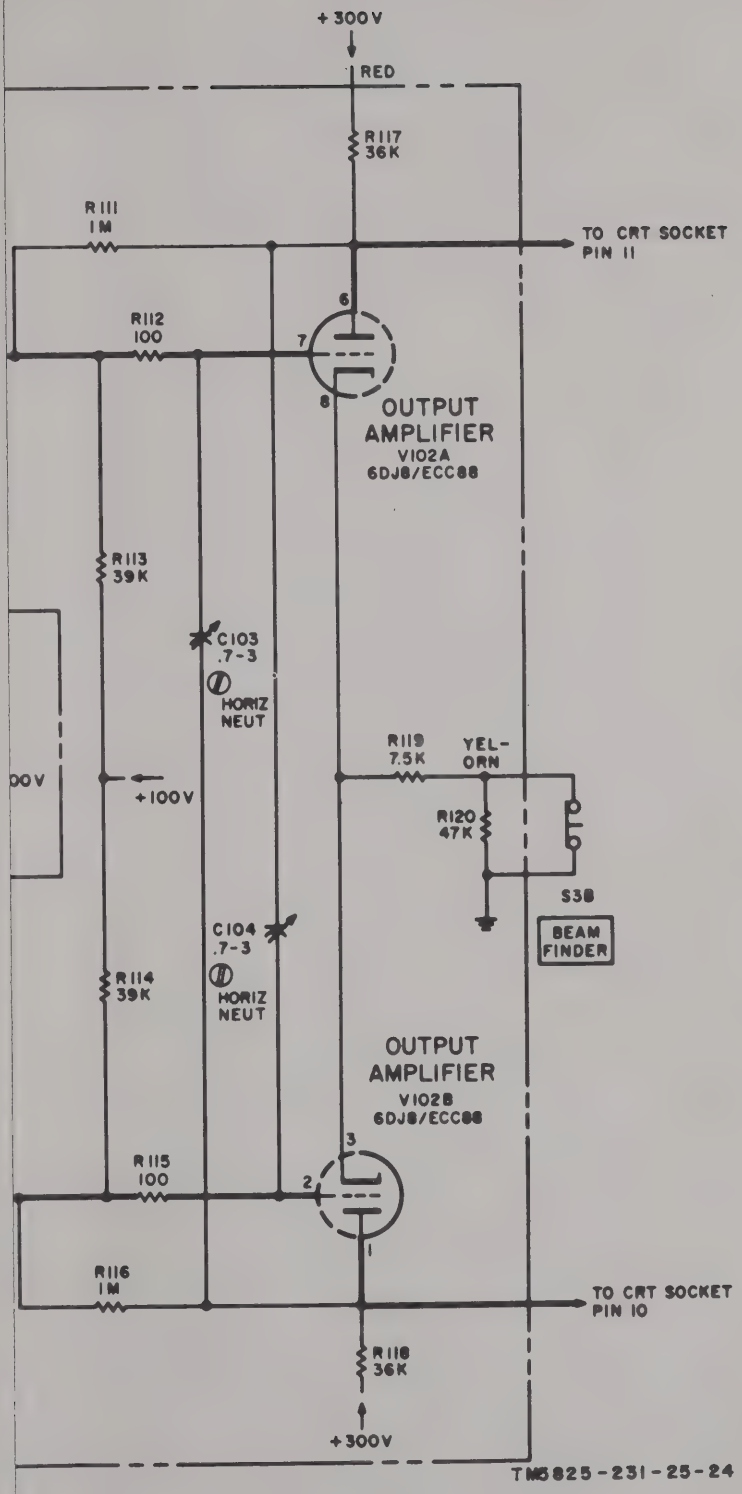
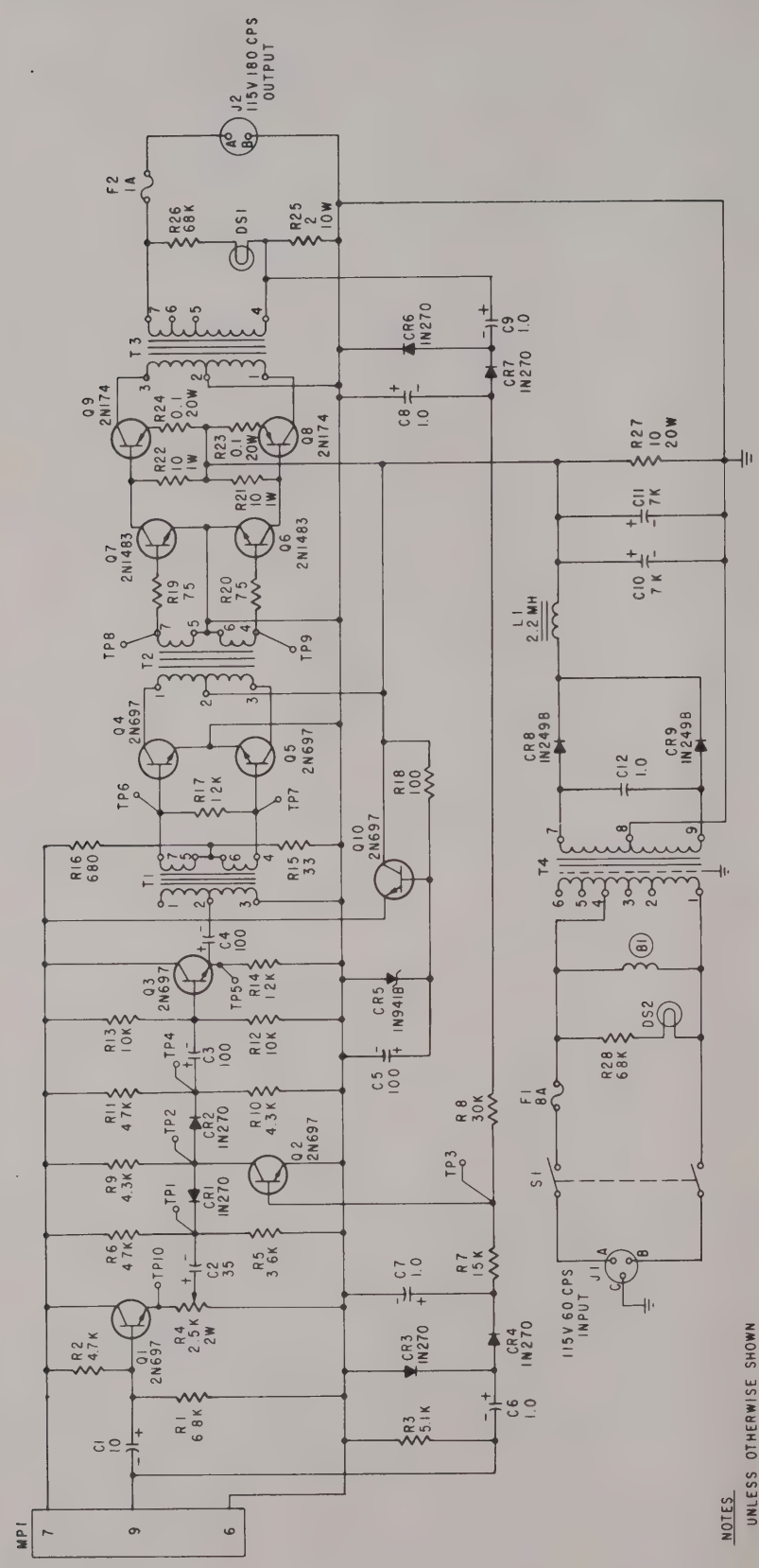


Figure 6-20. Electronic control amplifier, schematic diagram.

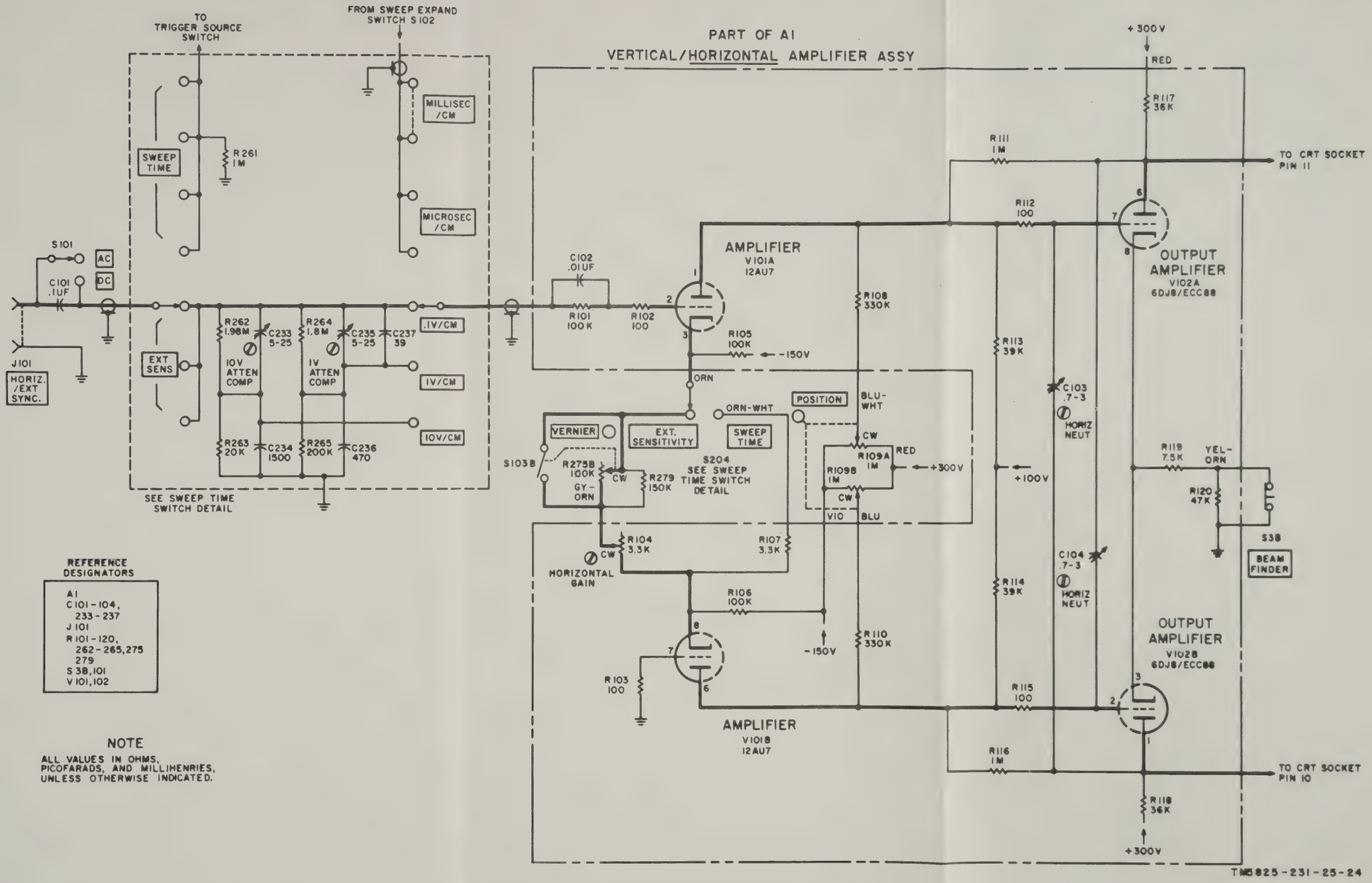

+300V
RED
R117
36K
R111
1M
TO CRT SOCKET
PIN 11
6
R112
100
7
8
OUTPUT
AMPLIFIER
V102A
6DJ8/ECC88
R113
39K
C103
.7-3
HORIZ
NEUT
R119
7.5K
YEL-
ORN
+100V
R120
47K
S38
BEAM
FINDER
C104
.7-3
R114
39K
HORIZ
NEUT
OUTPUT
AMPLIFIER
V102B
6DJ8/ECC88
3
R115
100
2
1
R116
1M
TO CRT SOCKET
PIN 10
R118
36K
+300V
TM5825-231-25-24



NOTES
UNLESS OTHERWISE SHOWN
RESISTORS ARE IN OHMS 1/2 W ±10%
CAPACITORS ARE IN UF

TM 5825-231-25-16

Figure 6-20. Electronic control amplifier, schematic diagram.



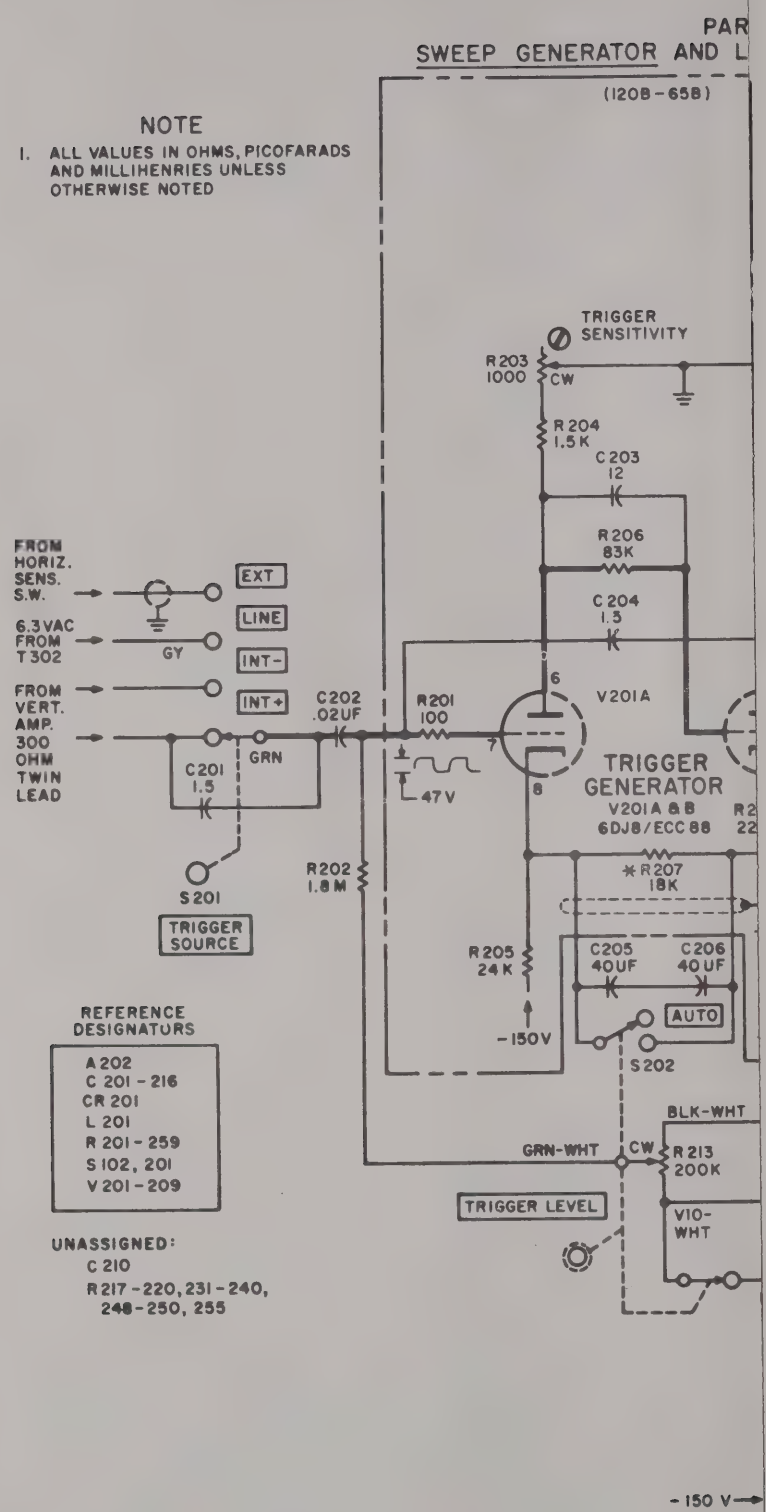
REFERENCE DESIGNATORS

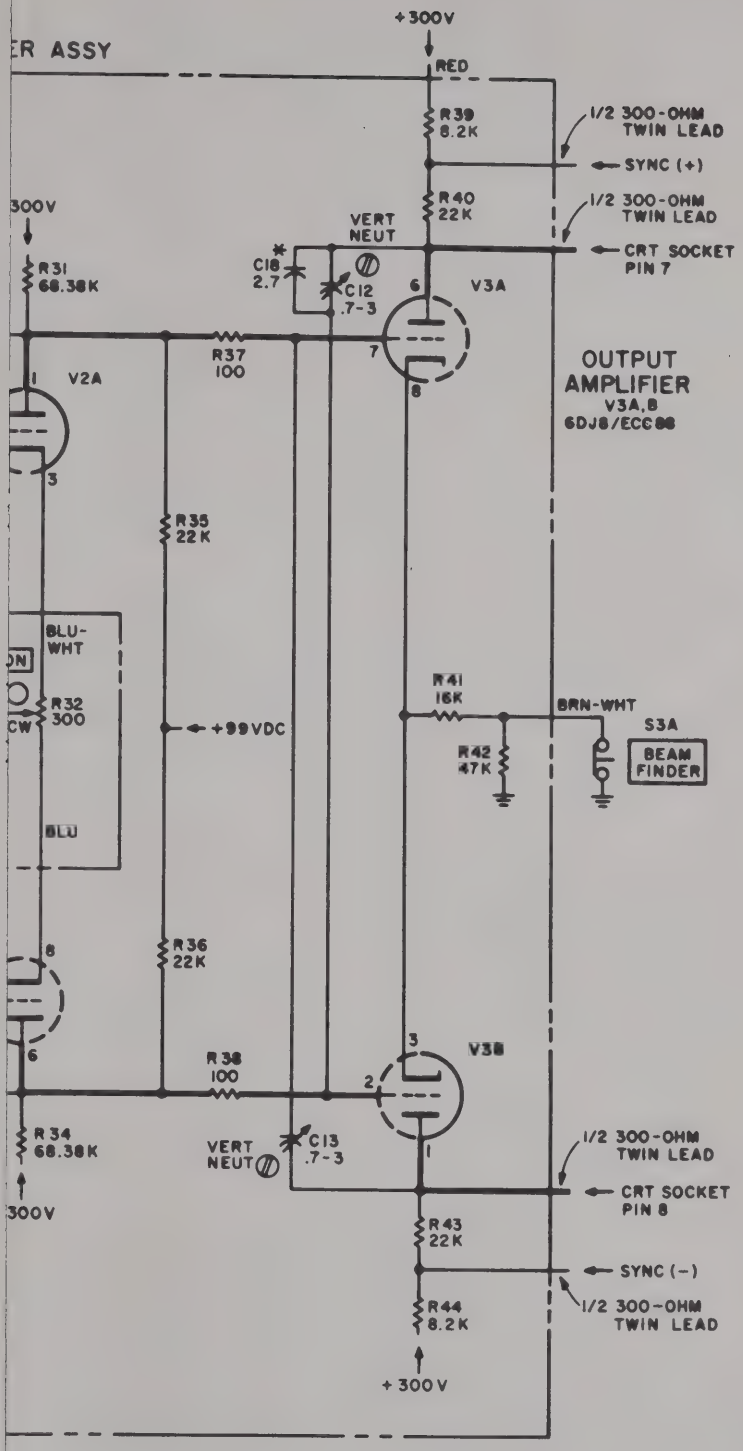
A1
C101-104, 233-237
J101
R101-120, 262-265,275 279
S38,101
V101,102

NOTE

ALL VALUES IN OHMS, PICOFARADS, AND MILLIHENRIES, UNLESS OTHERWISE INDICATED.

Figure 6-21. Horizontal amplifier, oscilloscope, schematic diagram.


PAR
SWEEP GENERATOR AND L
(1208-658)
NOTE
1. ALL VALUES IN OHMS, PICOFARADS AND MILLIHENRIES UNLESS OTHERWISE NOTED
TRIGGER SENSITIVITY
R203 1000 CW
R204 1.5K
C203 12
R206 83K
C204 1.5
FROM HORIZ. SENS. S.W.
6.3 VAC FROM T302
GY
FROM VERT. AMP. 300 OHM TWIN LEAD
EXT
LINE
INT-
INT+
C202 .02UF
R201 100
V201A
TRIGGER GENERATOR
V201A & B 6DJ8/ECC 88
47V
C201 1.5
GRN
S201
TRIGGER SOURCE
R202 1.8M
*R207 18K
R205 24K
C205 40UF
C206 40UF
AUTO
-150V
S202
REFERENCE DESIGNATORS
A 202
C 201-216
CR 201
L 201
R 201-259
S 102, 201
V 201-209
UNASSIGNED:
C 210
R 217-220, 231-240, 248-250, 255
BLK-WHT
GRN-WHT
CW
R213 200K
TRIGGER LEVEL
V10-WHT
-150 V



TM 5825-231-25-22

PART OF A202
SWEEP GENERATOR AND LOW VOLTAGE POWER SUPPLY ASSY.
(1208-658)

NOTE
1. ALL VALUES IN OHMS, PICOFARADS AND MILLIHENRIES UNLESS OTHERWISE NOTED

REFERENCE DESIGNATORS
A 202
C 201 - 216
CR 201
L 201
R 201 - 259
S 102, 201
V 201 - 209

UNASSIGNED:
C 210
R 217 - 220, 231 - 240, 248 - 250, 255

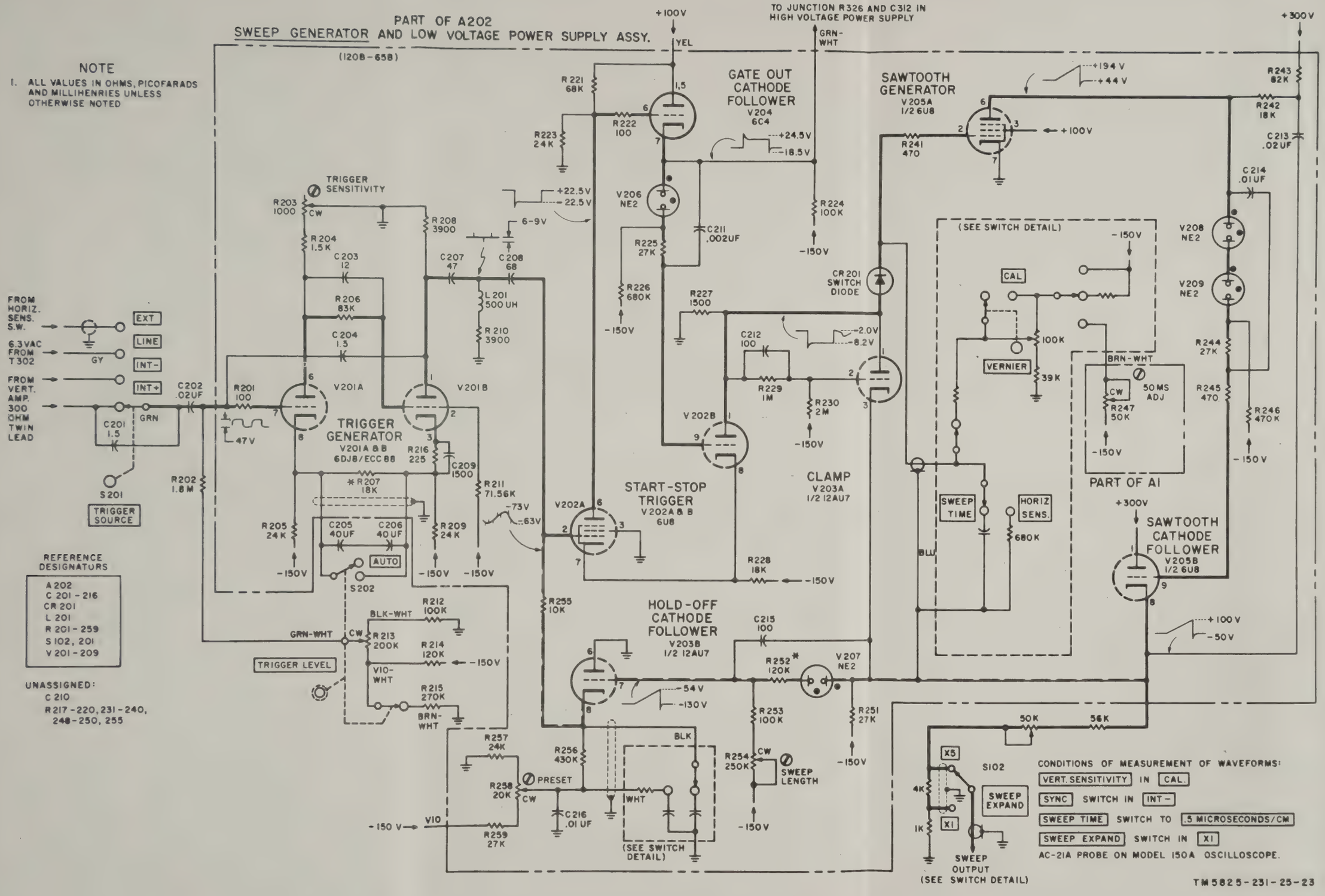
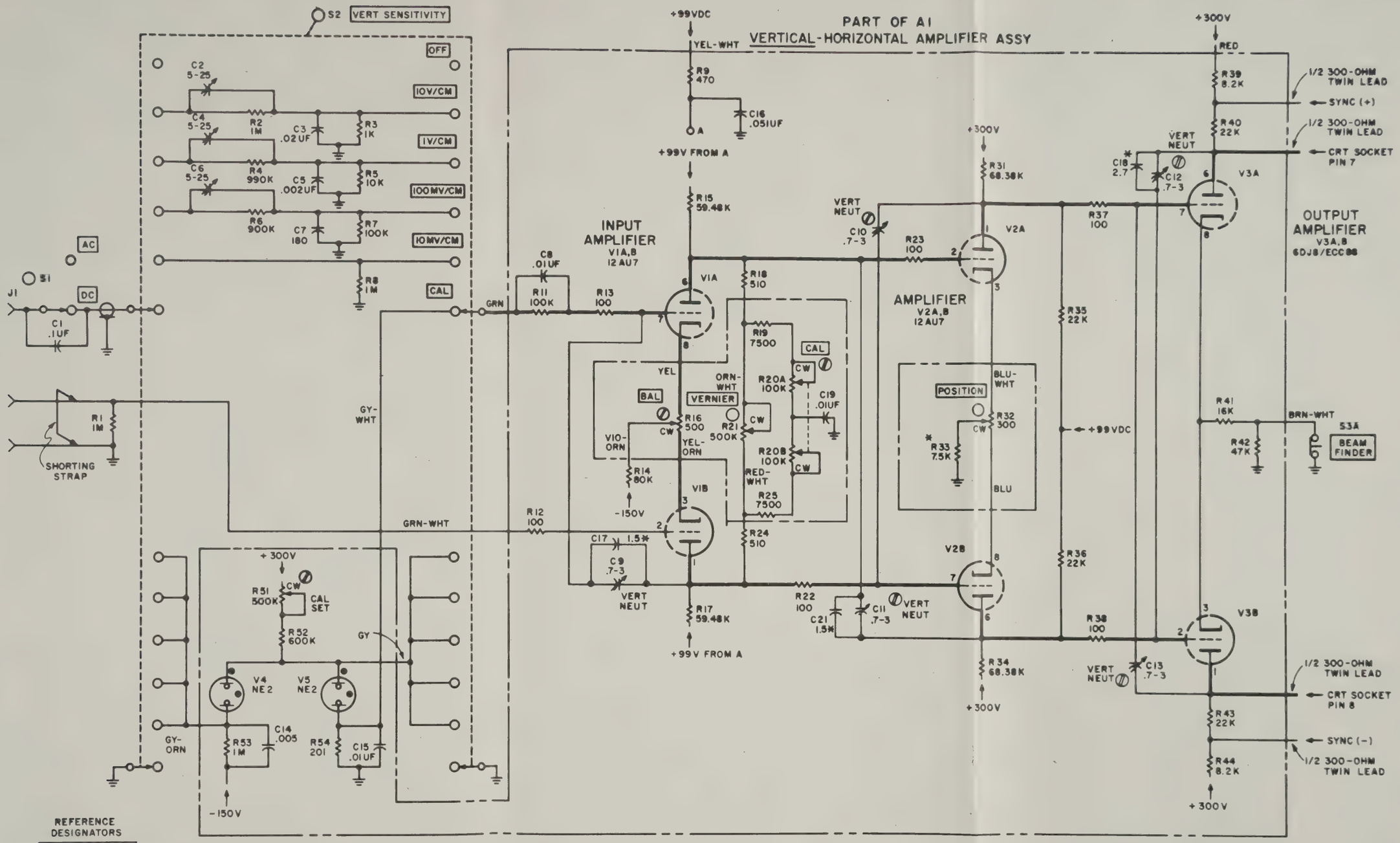


Figure 6–22. Sweep generator, oscilloscope, schematic diagram.



REFERENCE DESIGNATORS

A1
C1 - 21
J1
R1 - 54
S1 - 3
V1 - 5

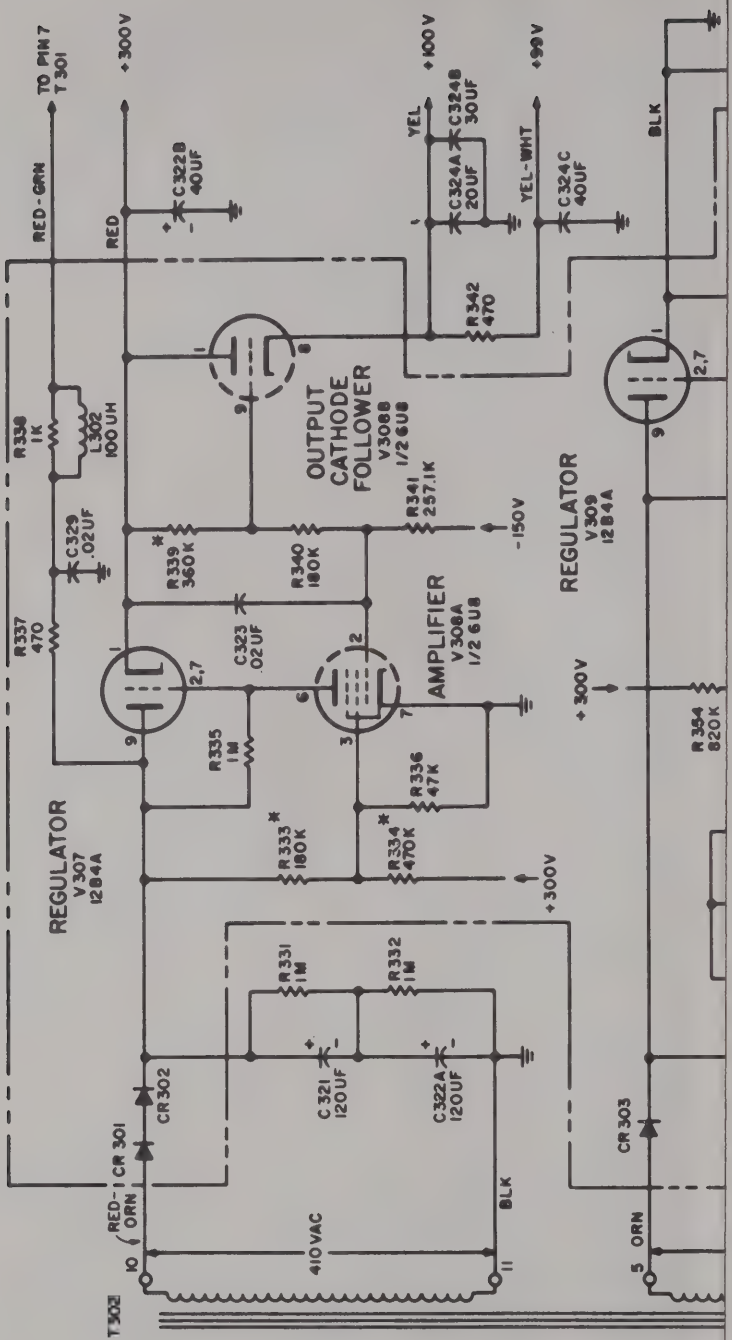
UNASSIGNED:
C20
R10, 26-30, 45-50

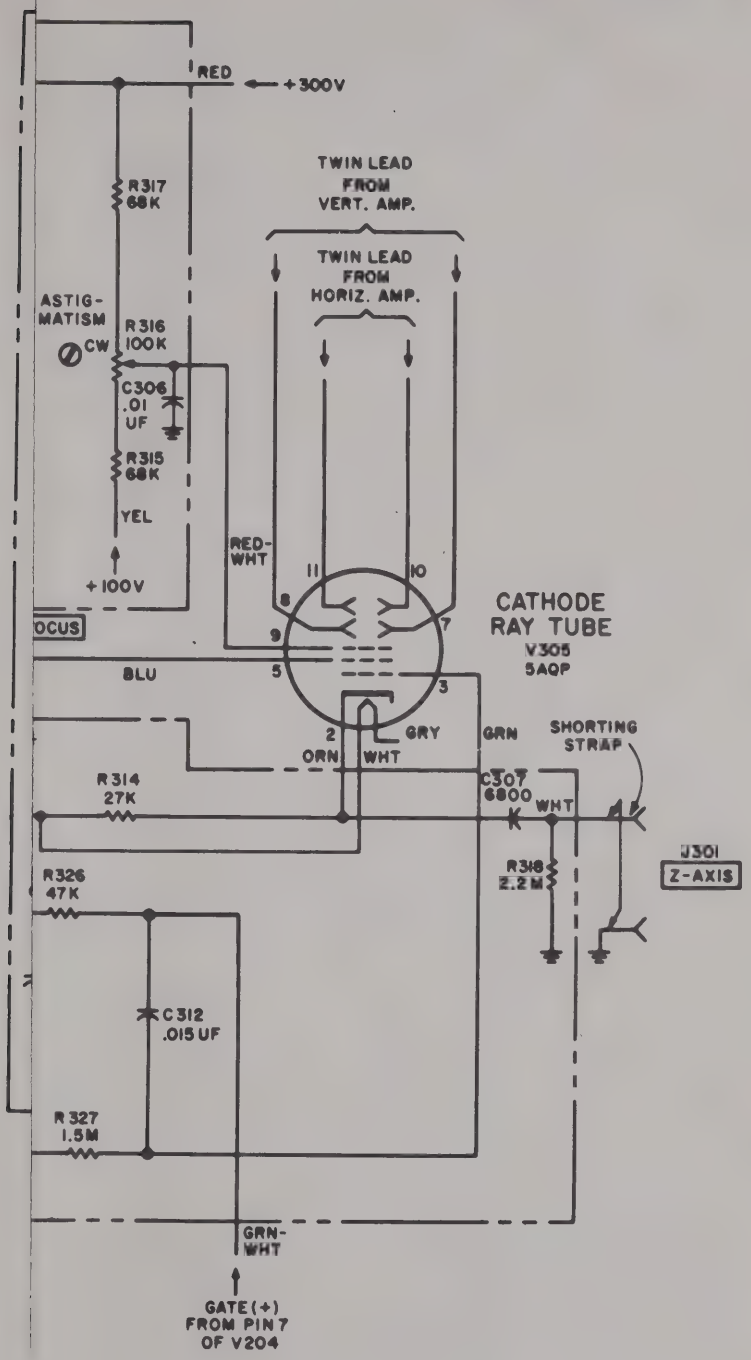
NOTES

1. ALL VALUES ARE IN OHMS, PICOFARADS AND MILLIHENRIES, UNLESS OTHERWISE INDICATED.
2. * - AVERAGE VALUE SHOWN: OPTIMUM VALUE SELECTED AT FACTORY, PART MAY BE OMITTED.

TM 5825-231-25-22

Figure 6-23. Vertical amplifier, oscilloscope, schematic diagram.


TO PIN 7 T 301
+300V
RED-GRN
RED
C322B 40UF
YEL
+100V
C324B 30UF
C324A 20UF
YEL-WHT
+99V
C324C 40UF
BLK
R342 470
OUTPUT CATHODE FOLLOWER V306B 1/2 6U8
R341 257.1K
-150V
R338 1K
L302 100 UH
C329 .02UF
R339* 360K
R340 180K
R337 470
C323 .02UF
AMPLIFIER V306A 1/2 6U8
REGULATOR V309 12B4A
+300V
R354 820K
R335 1M
R336 47K
REGULATOR V307 12B4A
R333* 180K
R334* 470K
+300V
R331 1M
R332 1M
C321 120UF
C322A 120UF
CR 302
CR 301
CR 303
RED-ORN
410VAC
BLK
5 ORN
T302



TM5825-231-25-26

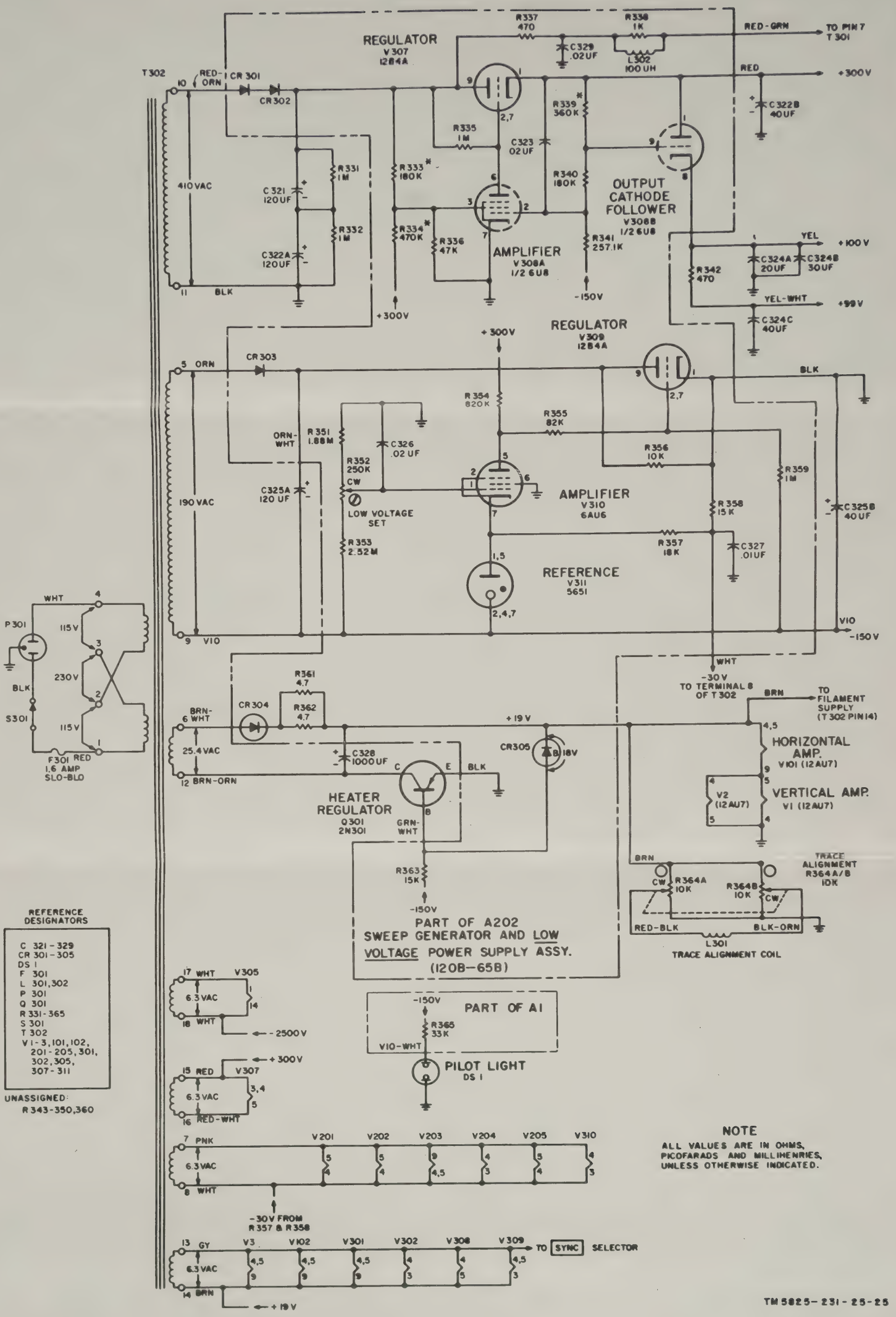


Figure 6-24. Low voltage power supply, oscilloscope, schematic diagram.

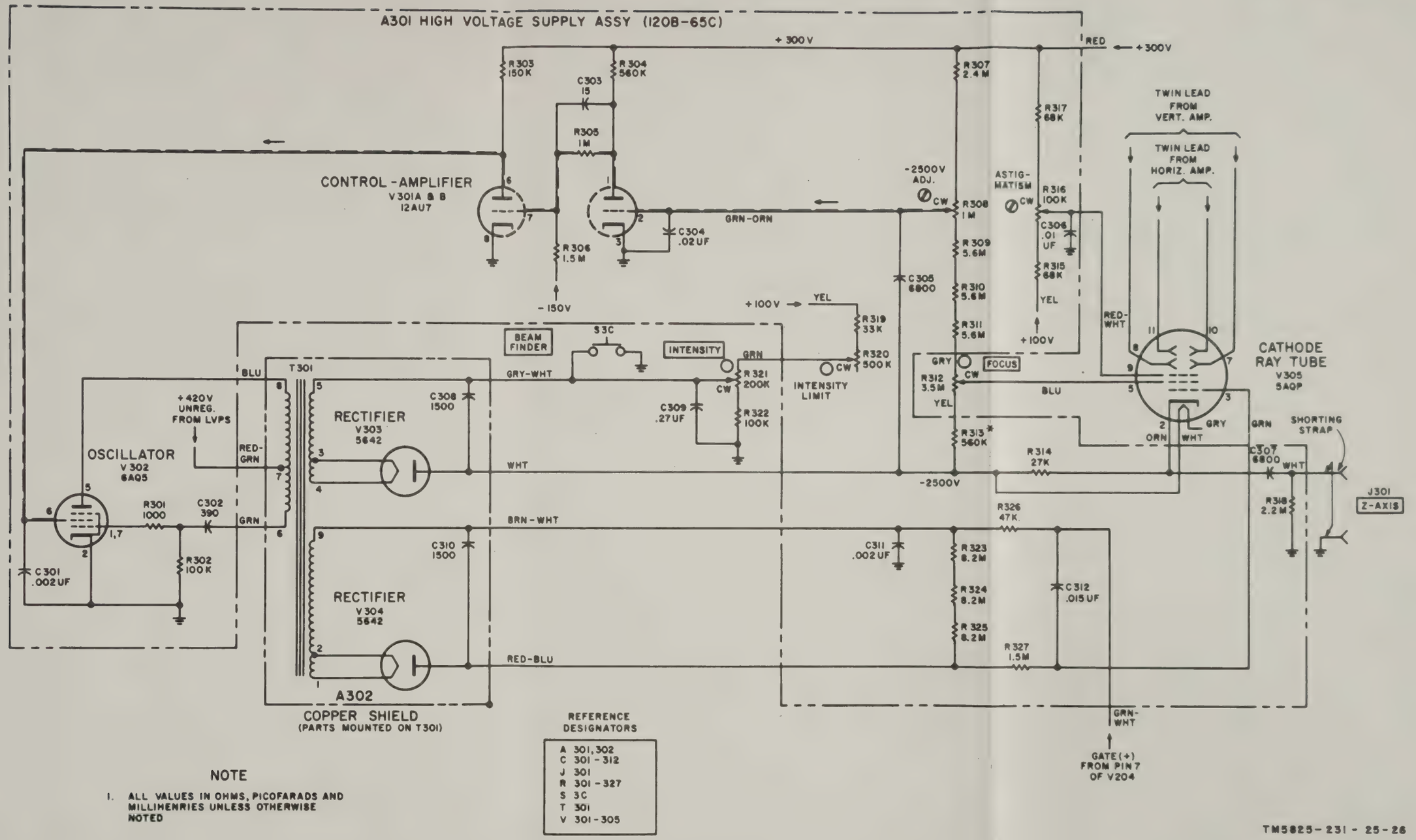
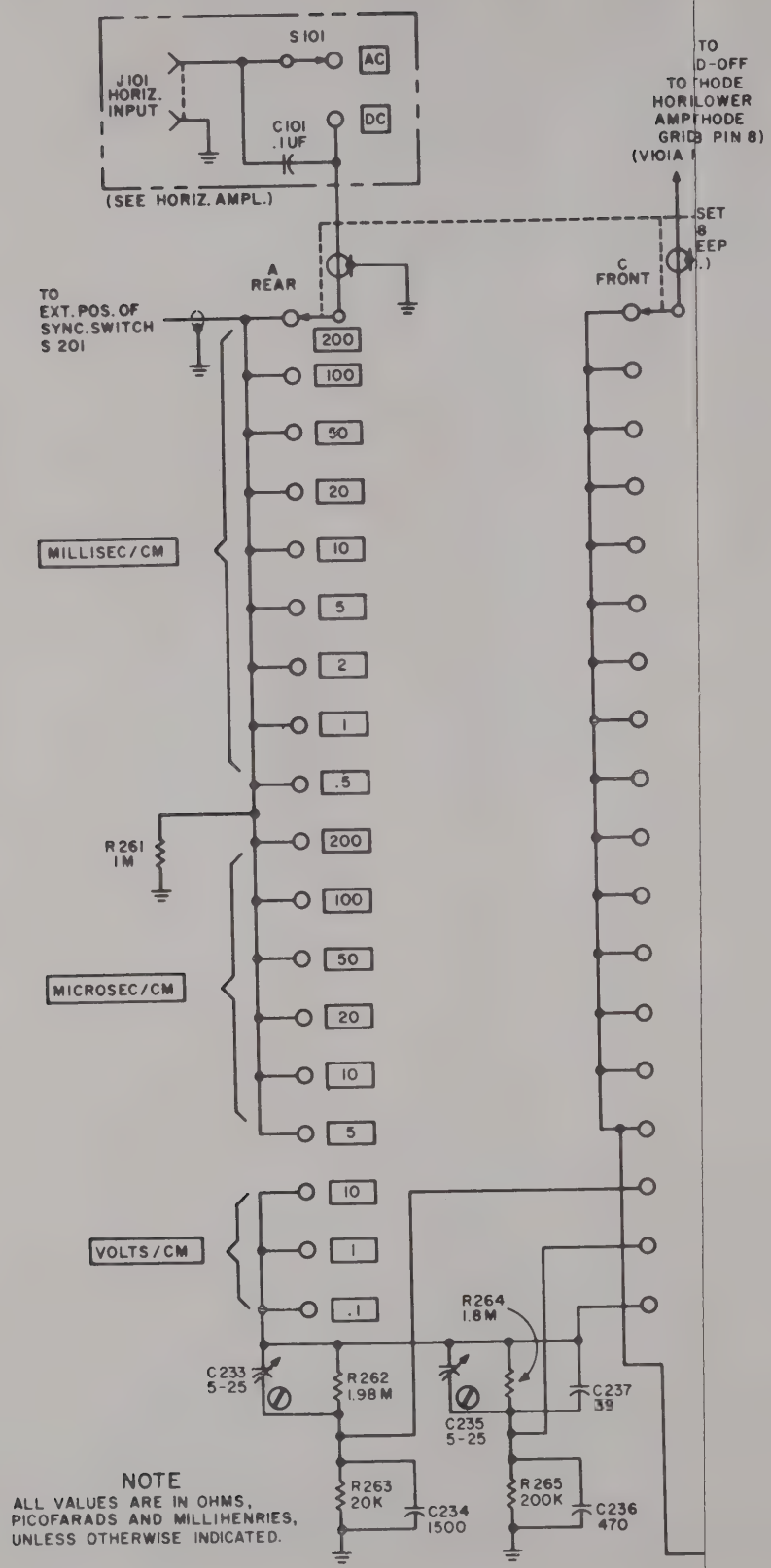


Figure 6–25. High voltage power supply, oscilloscope, schematic diagram.


S101
AC
DC
J101 HORIZ. INPUT
C101 .1UF
(SEE HORIZ. AMPL.)
TO D-OFF
TO CATHODE HORI LOWER AMP CATHODE GRID (V101A PIN 8)
SET & EEP
A REAR
C FRONT
TO EXT. POS. OF SYNC. SWITCH S 201
200
100
50
20
10
5
2
1
.5
MILLISEC/CM
R261 1M
200
100
50
20
10
5
MICROSEC/CM
10
1
.1
VOLTS/CM
R264 1.8M
C233 5-25
R262 1.98M
C235 5-25
C237 39
R263 20K
C234 1500
R265 200K
C236 470
NOTE
ALL VALUES ARE IN OHMS, PICOFARADS AND MILLIHENRIES, UNLESS OTHERWISE INDICATED.

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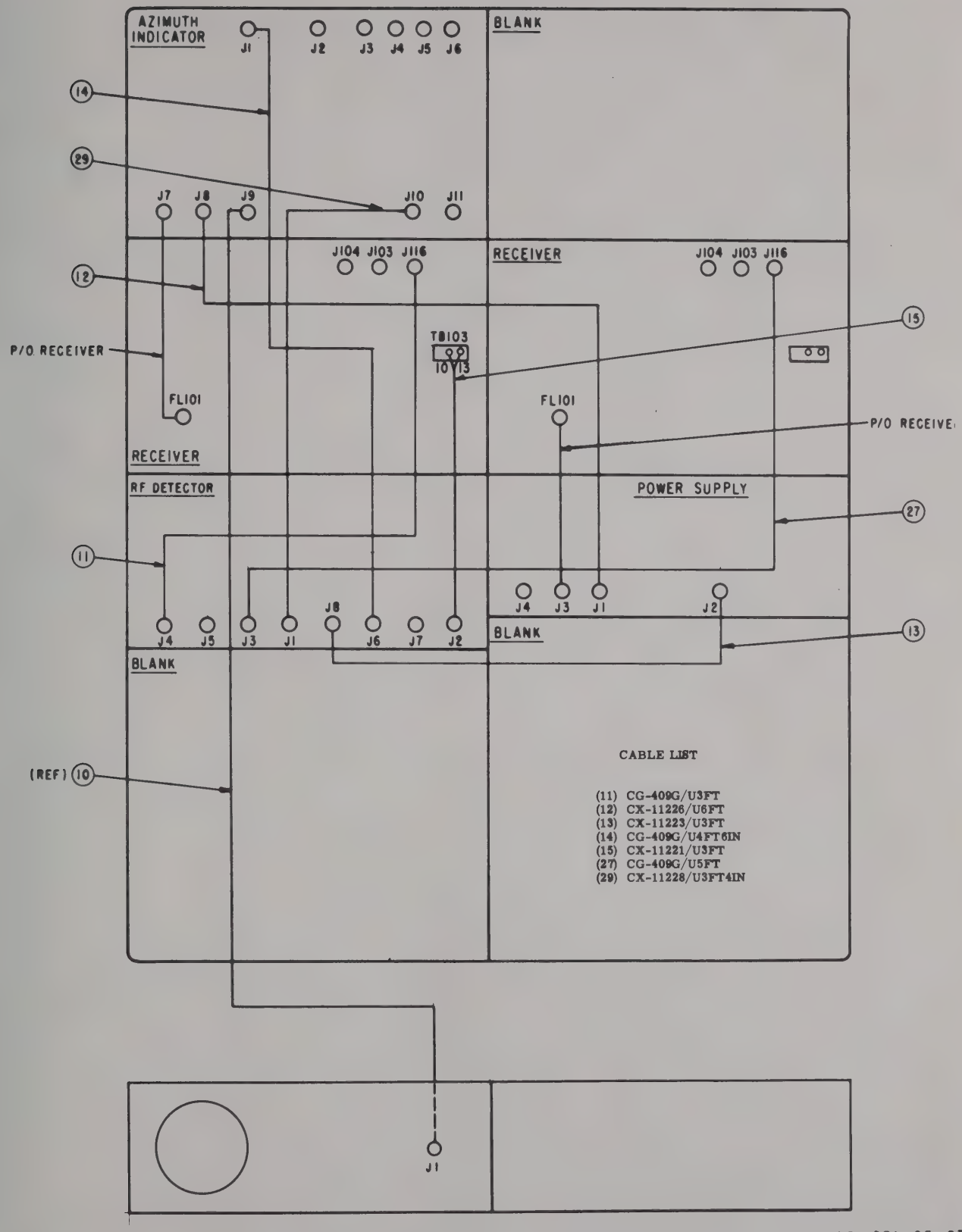


Figure 6–27. Secondary console assembly, cabling diagram.

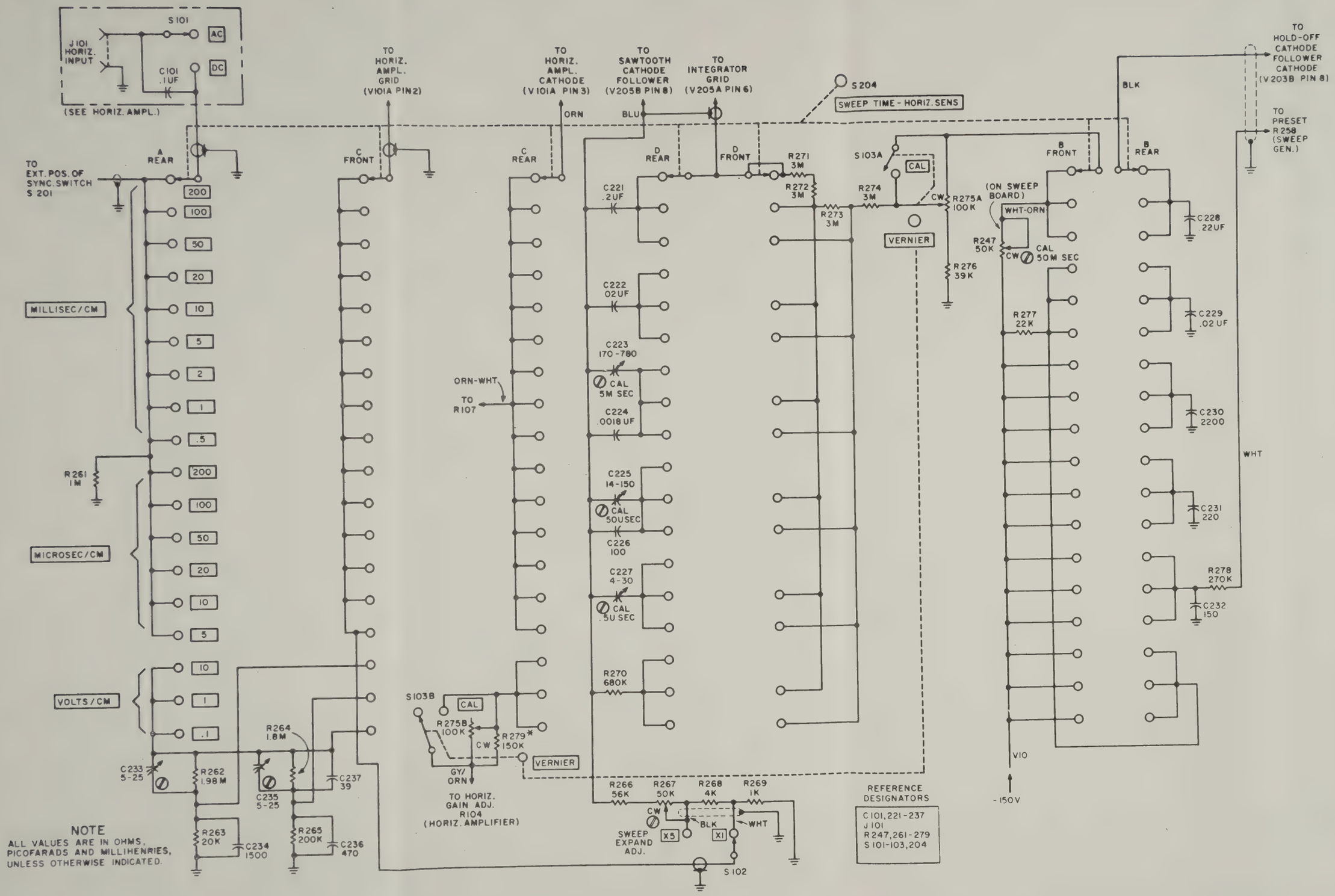


Figure 6–26. Horizontal display switch, schematic diagram.

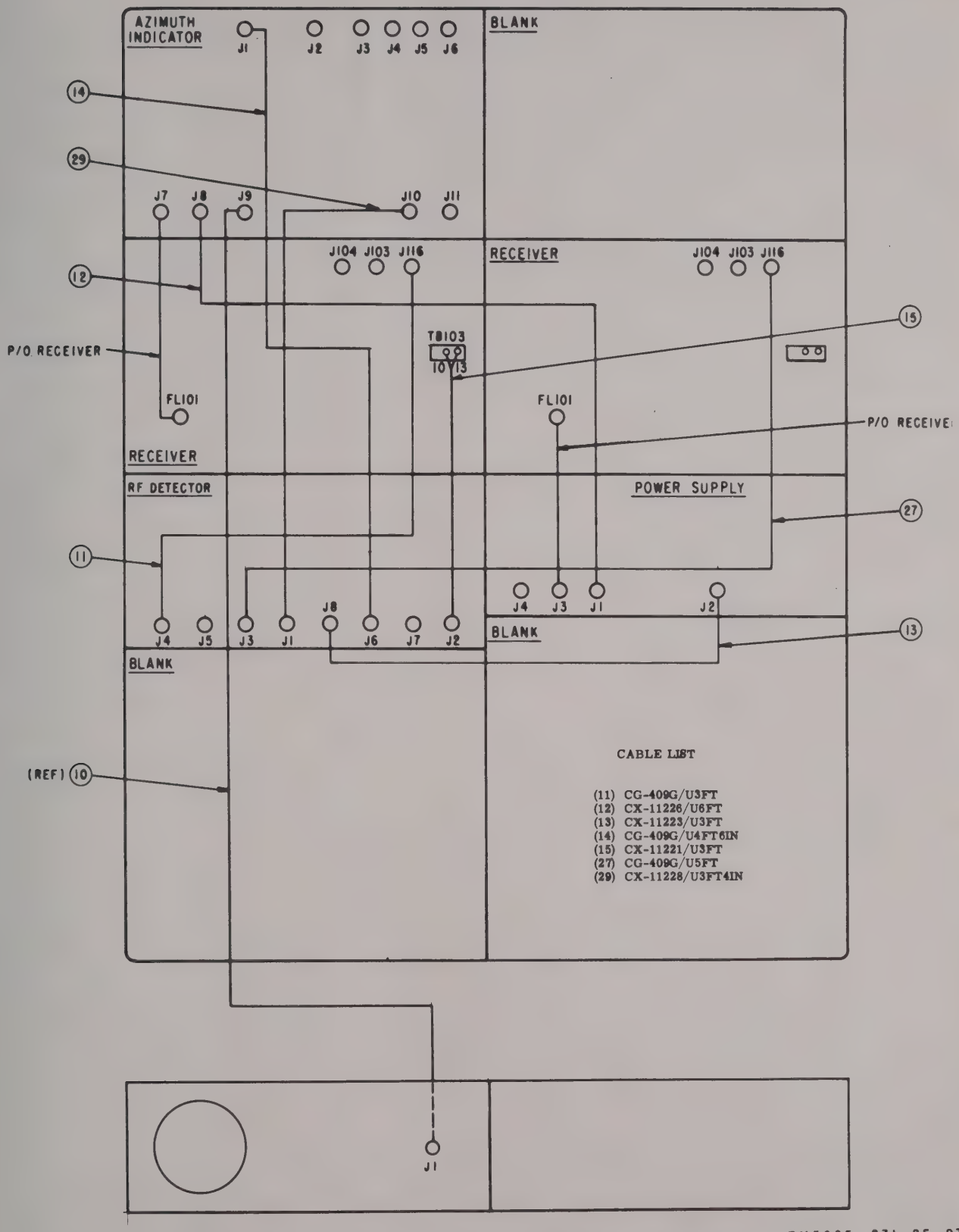
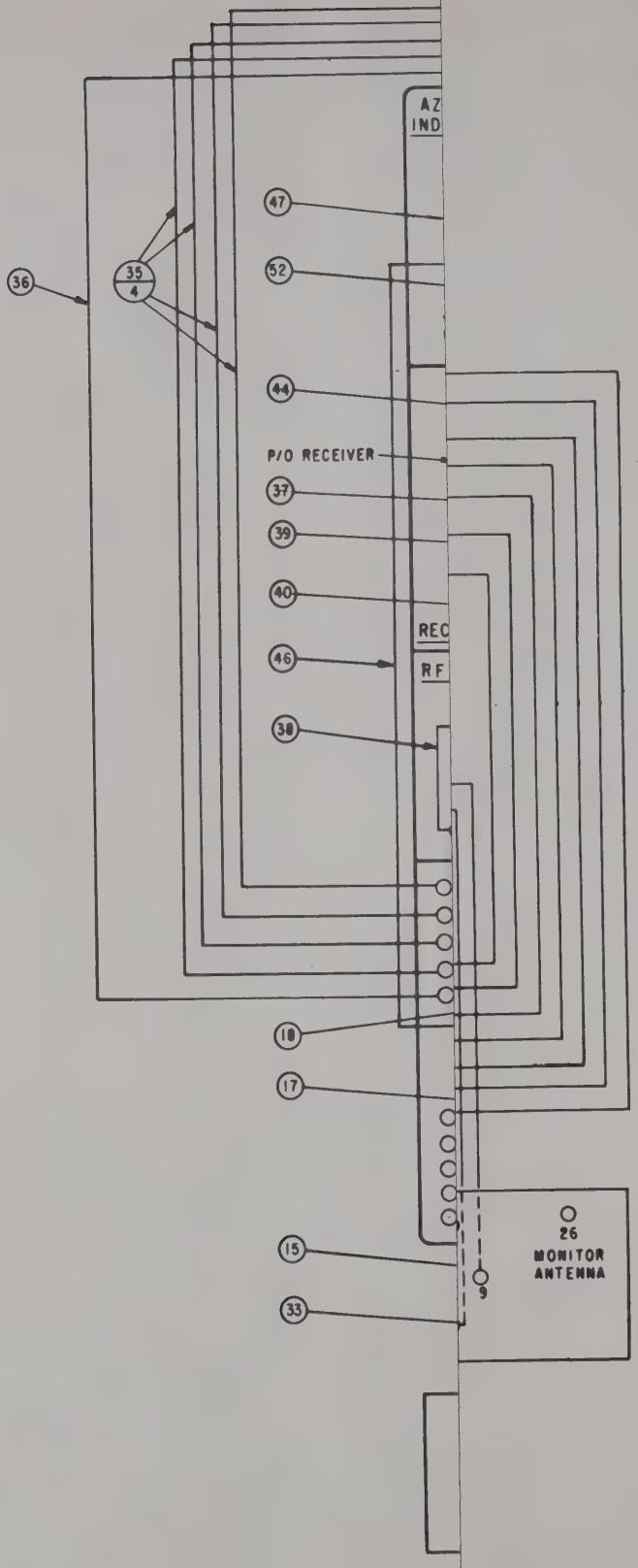


Figure 6-27. Secondary console assembly, cabling diagram.

CABLE LIST

(14) CG-3211/U1FT
(15) CX-11222/U3FT6IN
(16) CX-11224/U2FT6IN
(17) CG-1079B/U2FT
(18) CG-1079B/U2FT6IN
(33) CG-3178/TRD
(35) CG-409G/U6FT
(36) CG-1079B/U6FT
(37) CX-11221/U3FT
(38) CG-409G/U3FT
(39) CG-833A/U4FT6IN
(40) CG-1079B/U5FT6IN
(41) CX-11180/U5FT6IN
(42) CG-409G/U5FT6IN
(43) CG-409G/U6FT6IN
(44) CX-11226/U6FT
(45) CX-11223/U3FT
(46) CX-11480/U5FT
(47) CG-409G/U4FT6IN
(48) CG-833A/U5FT
(49) CG-409G/U5FT
(52) CX-11228/U3FT4IN



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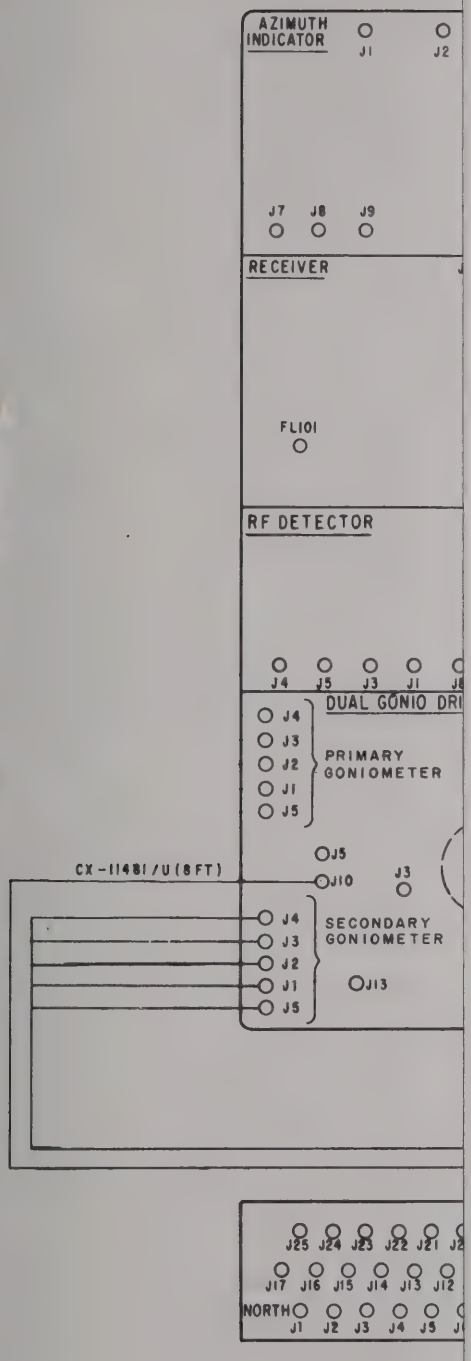
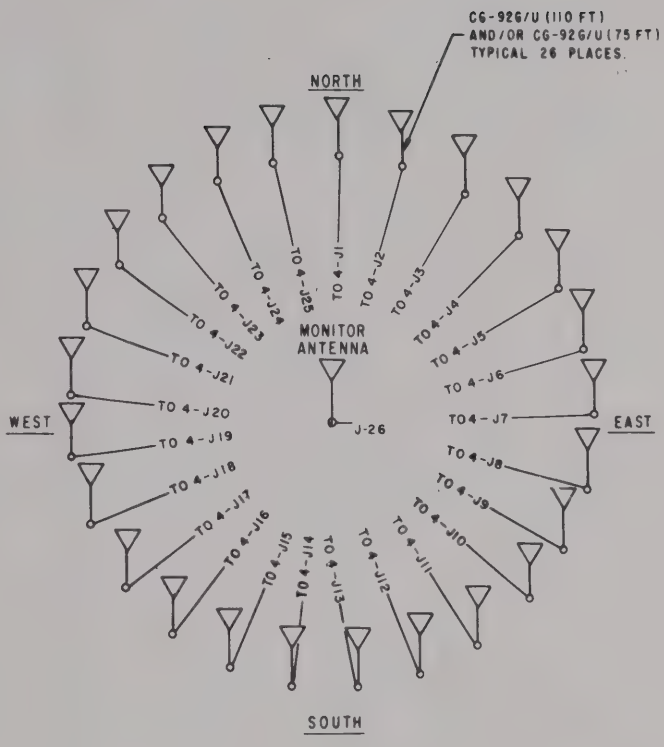

AZIMUTH INDICATOR
J1
J2
J7
J8
J9
RECEIVER
FL101
RF DETECTOR
J4
J5
J3
J1
DUAL GONIO DRI
J4
J3
J2
J1
J5
PRIMARY GONIOMETER
J5
J10
J3
CX-11481/U (8 FT)
J4
J3
J2
J1
J5
SECONDARY GONIOMETER
J13
J25
J24
J23
J22
J21
J17
J16
J15
J14
J13
J12
NORTH
J1
J2
J3
J4
J5


CG-926/U (110 FT) AND/OR CG-926/U (75 FT) TYPICAL 26 PLACES.
NORTH
MONITOR ANTENNA
J-26
TO 4-J1
TO 4-J2
TO 4-J3
TO 4-J4
TO 4-J5
TO 4-J6
TO 4-J7
TO 4-J8
TO 4-J9
TO 4-J10
TO 4-J11
TO 4-J12
TO 4-J13
TO 4-J14
TO 4-J15
TO 4-J16
TO 4-J17
TO 4-J18
TO 4-J19
TO 4-J20
TO 4-J21
TO 4-J22
TO 4-J23
TO 4-J24
TO 4-J25
WEST
EAST
SOUTH

CABLE LIST

(14) CG-3211/U1FT
(15) CX-11222/U3FT6IN
(16) CX-11224/U2FT6IN
(17) CG-1079B/U2FT
(18) CG-1079B/U2FT6IN
(33) CG-3178/TRD
(35) CG-409G/U6FT
(36) CG-1079B/U6FT
(37) CX-11221/U3FT
(38) CG-409G/U3FT
(39) CG-833A/U4FT6IN
(40) CG-1079B/U5FT6IN
(41) CX-11180/U5FT6IN
(42) CG-409G/U5FT6IN
(43) CG-409G/U6FT6IN
(44) CX-11226/U6FT
(45) CX-11223/U3FT
(46) CX-11480/U5FT
(47) CG-409G/U4FT6IN
(48) CG-833A/U5FT
(49) CG-409G/U5FT
(52) CX-11228/U3FT4IN

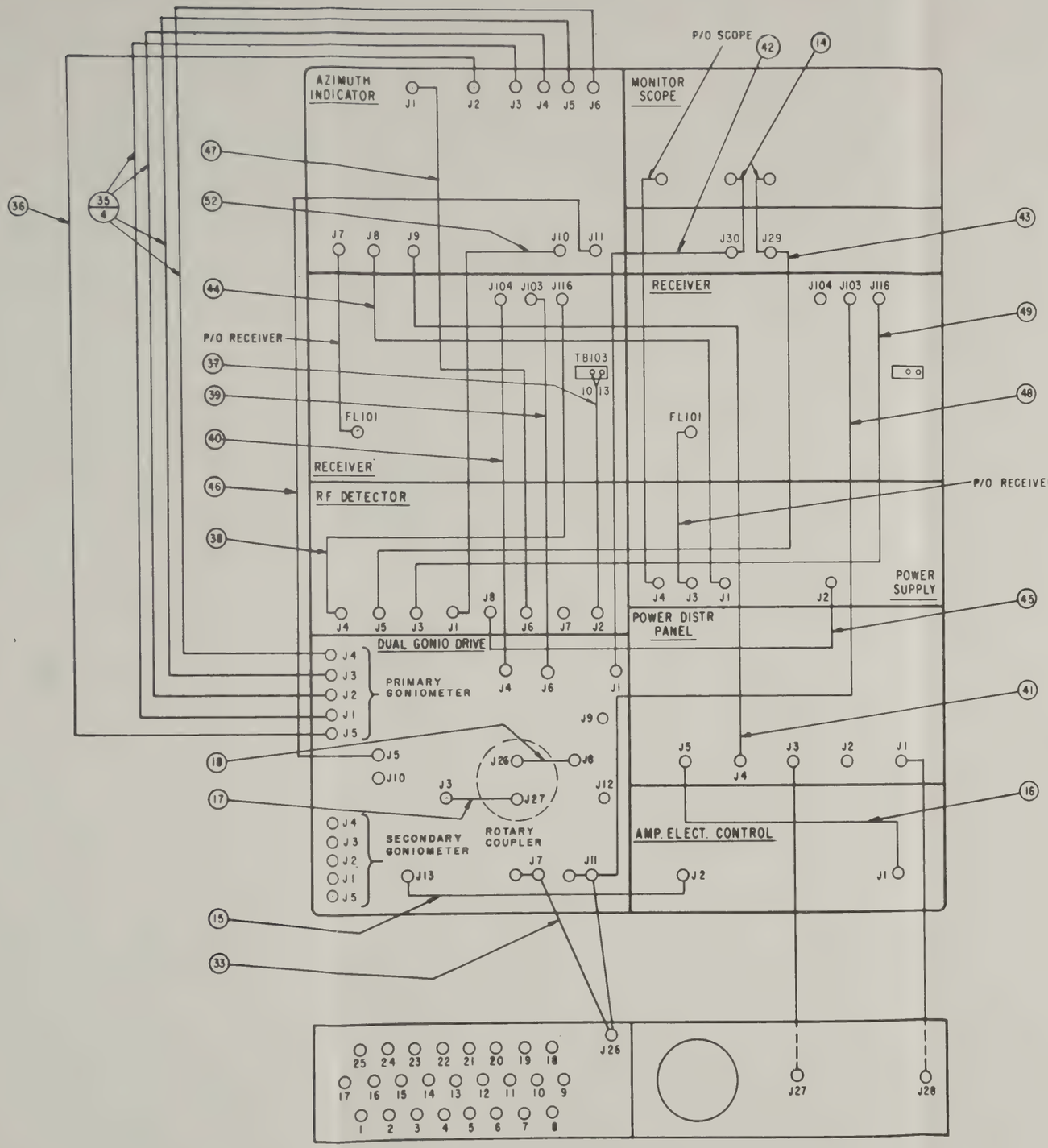


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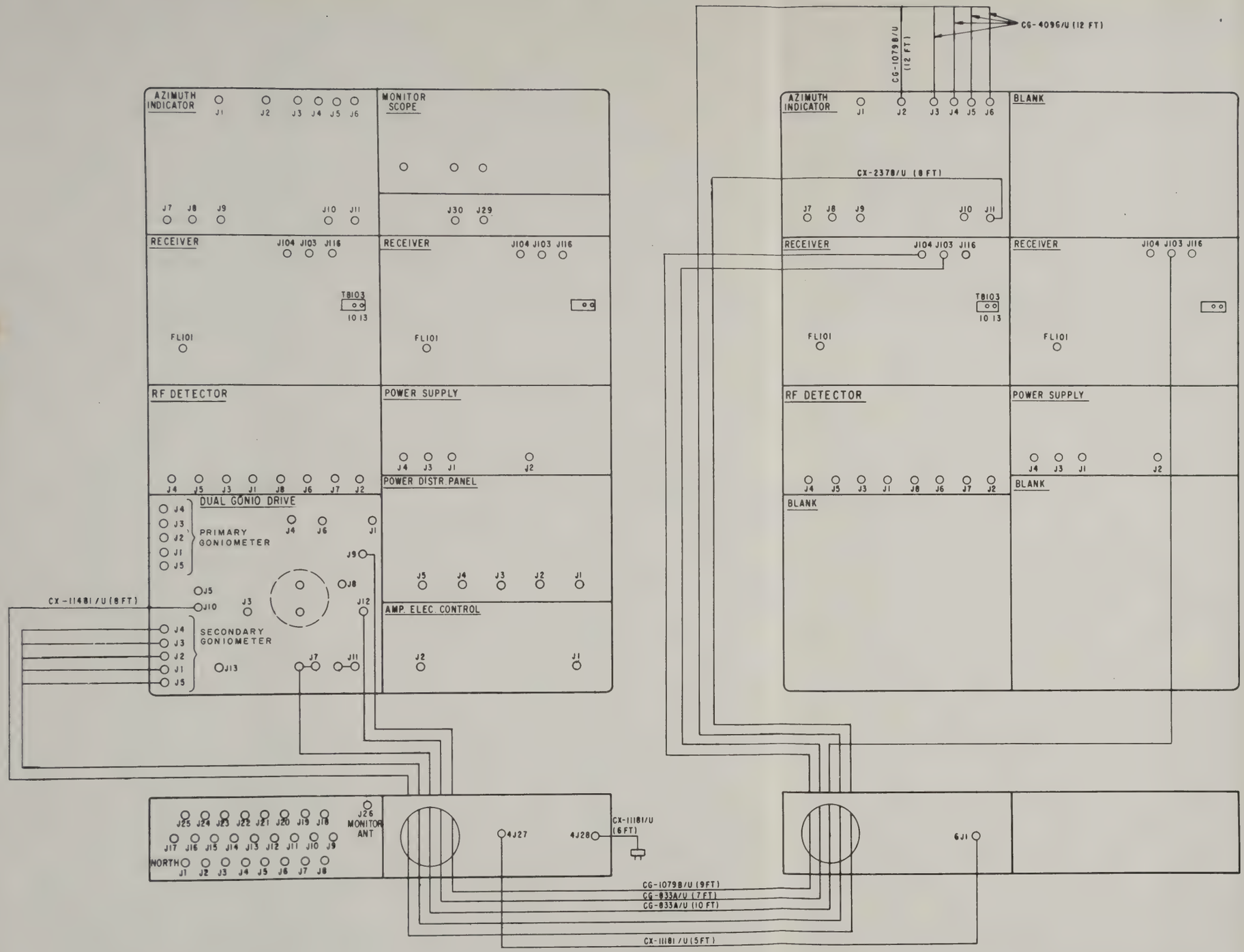
Figure 6-28. Primary console assembly, cabling diagram.



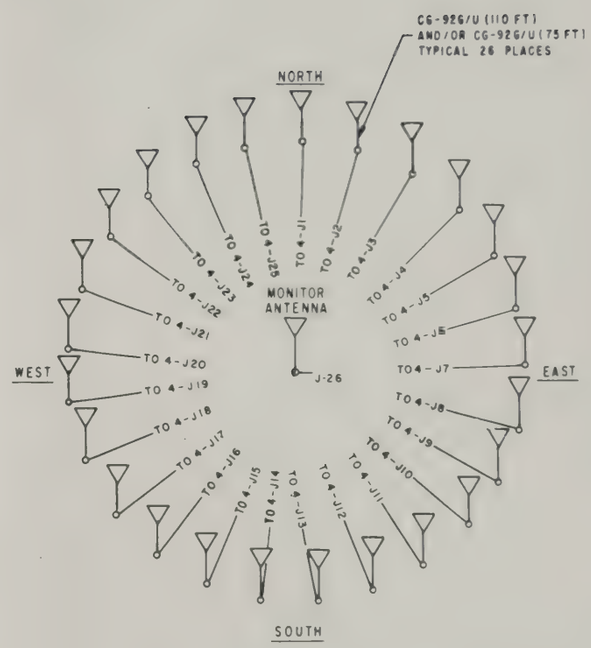
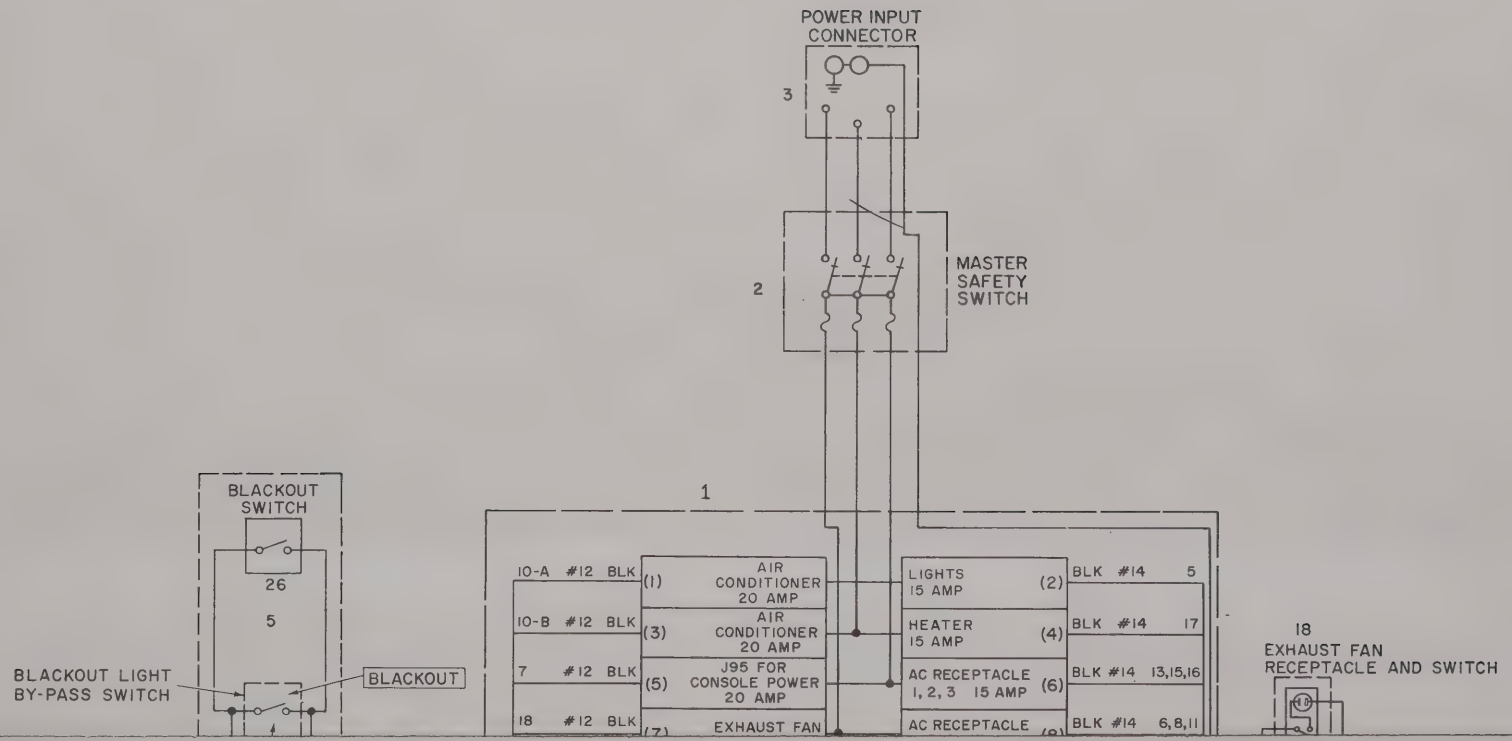


Figure 6–29. Direction finder AN/TRD–15, interunit cabling.


POWER INPUT CONNECTOR
3
2
MASTER SAFETY SWITCH
1
BLACKOUT SWITCH
26
5
BLACKOUT LIGHT BY-PASS SWITCH
BLACKOUT
10-A #12 BLK
(1) AIR CONDITIONER 20 AMP
LIGHTS 15 AMP (2)
BLK #14 5
10-B #12 BLK
(3) AIR CONDITIONER 20 AMP
HEATER 15 AMP (4)
BLK #14 17
7 #12 BLK
(5) J95 FOR CONSOLE POWER 20 AMP
AC RECEPTACLE 1, 2, 3 15 AMP (6)
BLK #14 13,15,16
18 #12 BLK
(7) EXHAUST FAN
AC RECEPTACLE (8)
BLK #14 6,8,11
18
EXHAUST FAN RECEPTACLE AND SWITCH

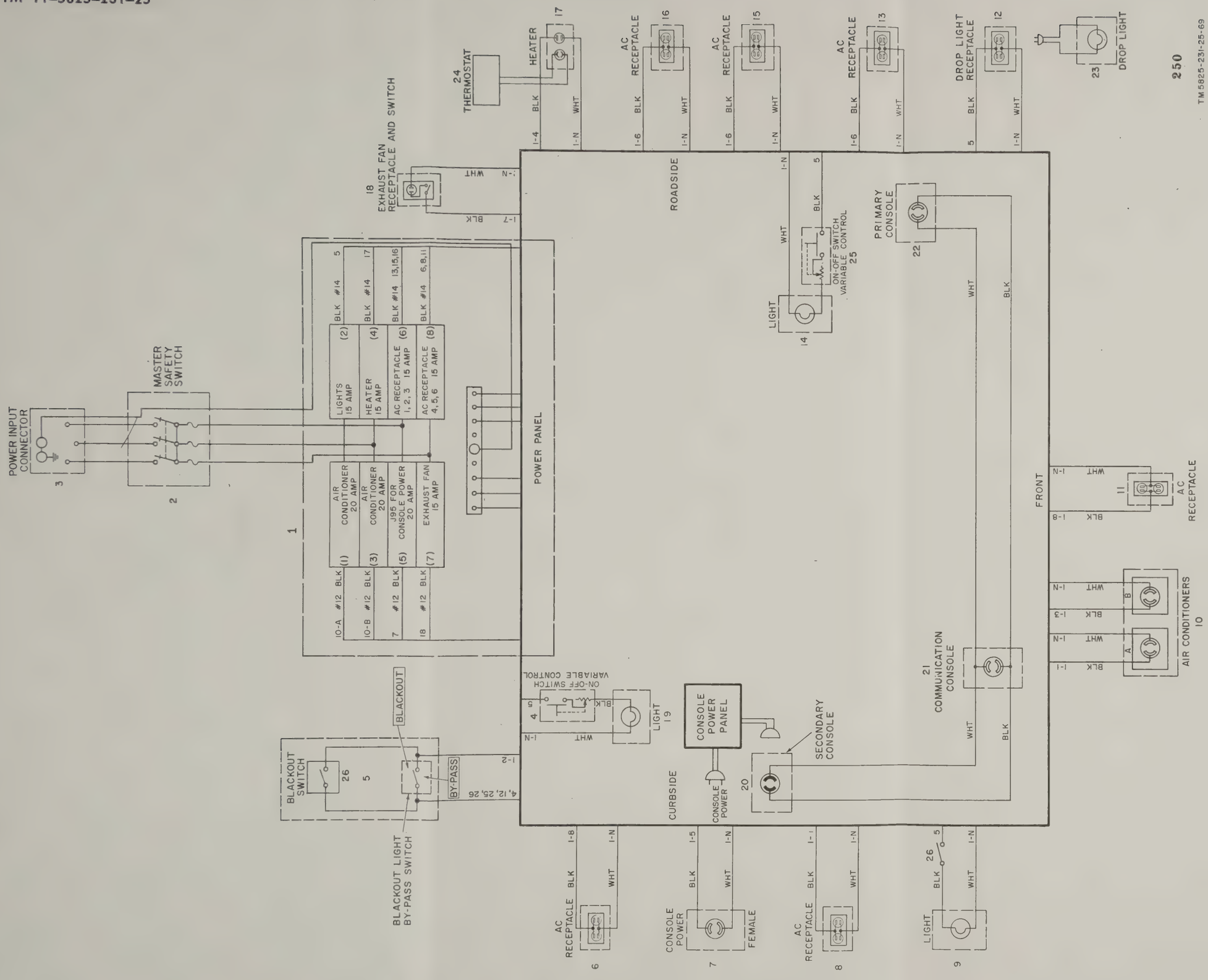


Figure 6-30. Direction Finder AN/TRD-23, shelter power, schematic diagram.

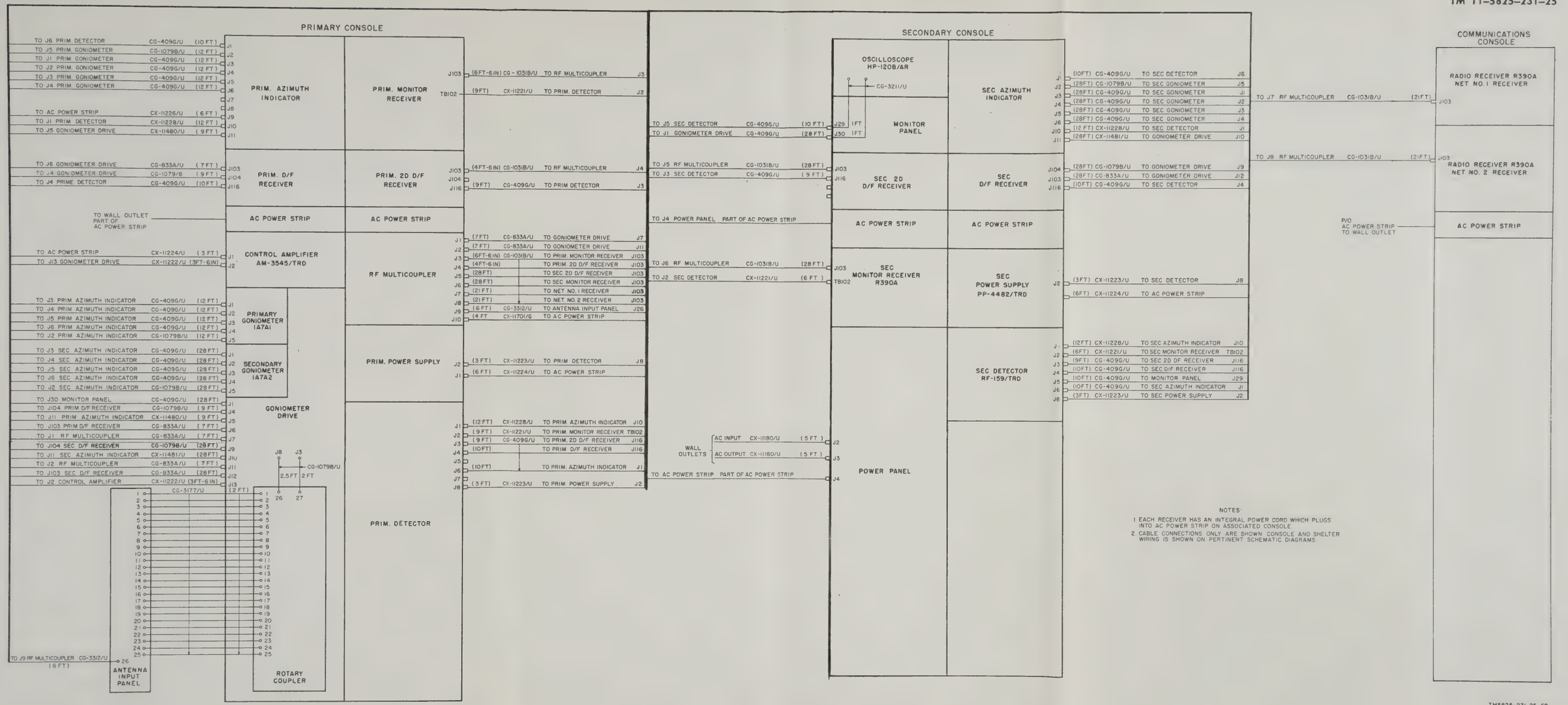


Figure 6–31. Direction Finder AN/TRD–23, cabling diagram.

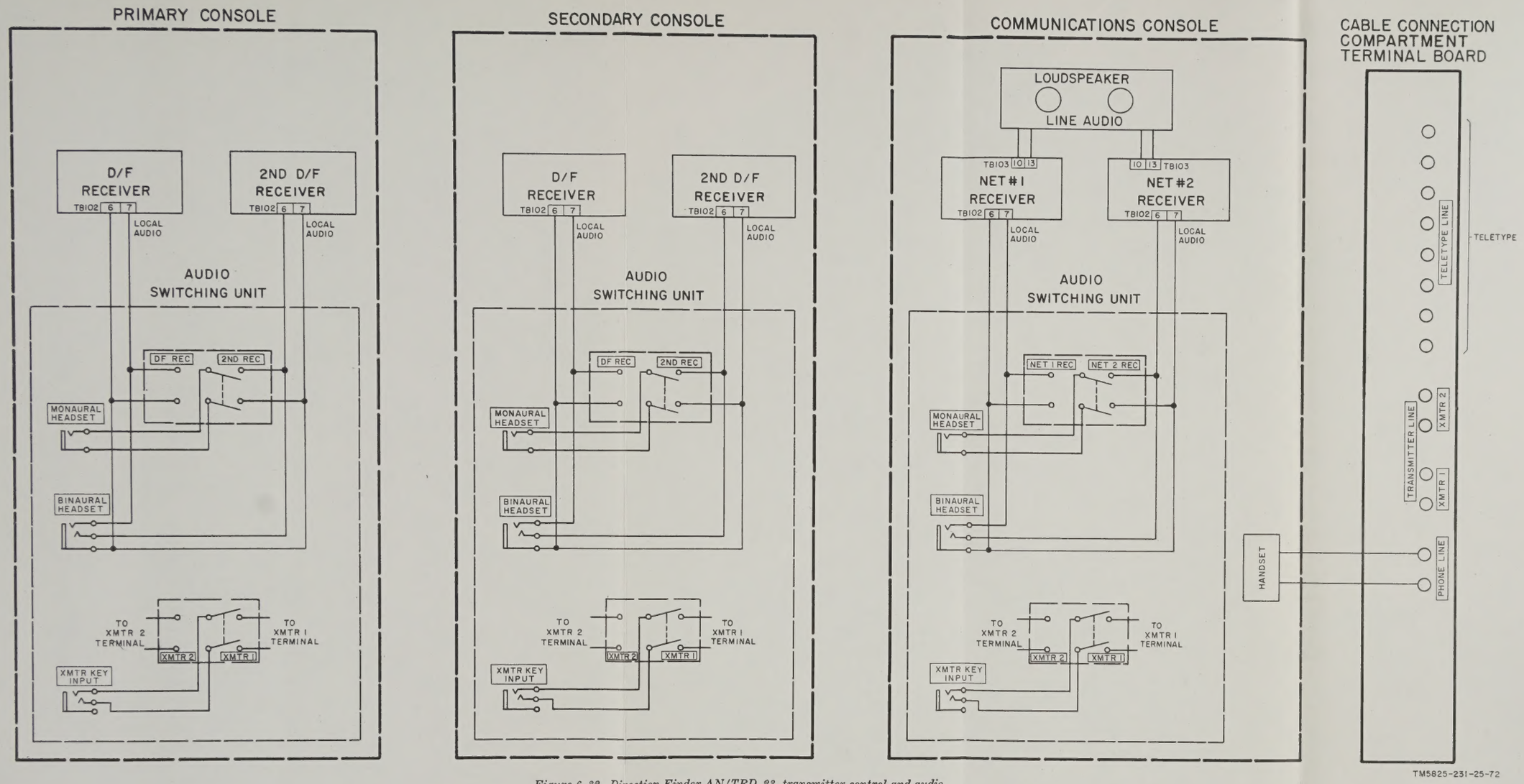


Figure 6–32. Direction Finder AN/TRD–23, transmitter control and audio switching, schematic diagram.